THE MASSACHUSETTS OCEAN MANAGEMENT TASK FORCE TECHNICAL REPORT

March, 2004

MASSACHUSETTS OCEAN MANAGEMENT TASK FORCE - MEMBERS

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ACKNOWLEDGEMENTS

The *Massachusetts Ocean Management Task Force Technical Report* (Volume 2) is the work of the Ocean Management Task Force (OMTF), staff, and other experts who supported the Task Force during its work. This Technical Report summarizes information provided to the Policy/Frameworks, Data Trends and Needs, and Use Characterization Working Group. The Task Force appreciates the leadership and hard work provided by Task Force Working Group Chairs including: Sue Tierney (Frameworks Working Group), Jim Hunt (Policy Working Group), Tom Skinner (Use Characterization Working Group), and Judy McDowell (Data Trends and Needs Working Group).

This volume reveals the basis for many of the Task Force recommendations and shares the wealth of information that was developed to support this effort. Several Task Force members in particular, along with state agency staff and private sector consultants, provided significant assistance in researching and drafting sections of this report and its companion Technical Report. These individuals are: Bill Adler (Massachusetts Lobstermen's Association), Mike Armstrong (Massachusetts Division of Marine Fisheries (DMF)), Deerin Babb-Brott (Massachusetts Coastal Zone Management (CZM)), Jay Baker (CZM), Priscilla Brooks (Conservation Law Foundation), Todd Callaghan (CZM), Dennis Ducsik (CZM), John Duff (U-Mass/Boston), Mike Egan (Carruth Capital), Bruce Estrella (DMF), Tom Hoopes (DMF), Jim Hunt (Massachusetts Environmental Policy Act (MEPA) office), Sarah Joor (CZM), Kate Killerlain (CZM), Judy McDowell (Woods Hole Oceanographic Institution), Vin Malkoski (DMF), Joe Pelczarski (CZM), Ann Pembroke (Normandeau Associates), Arthur Pugsley (MEPA), Tom Skinner (CZM), Susan Snow-Cotter (CZM), Megan Tyrrell (CZM), Greg Watson (Massachusetts Technology Collaborative), Alex White (CZM), and Tony Wilbur (CZM).

The Task Force would also like to acknowledge the generous financial assistance for the Ocean Management Initiative provided by the Massachusetts Environmental Trust and by the National Oceanic and Atmospheric Administration, without whose support this work would not have been possible.

INTRODUCTION

To advise the Massachusetts Ocean Management Initiative, Environmental Affairs Secretary Ellen Roy Herzfelder has named a Task Force to examine the current issues, identify data and information gaps, review existing ocean governance mechanisms, recommend state-wide planning principles, and issue recommendations for administrative, regulatory, and statutory changes. In response to this charge, the Ocean Management Task Force (OMTF) has developed two publications: *Waves of Change: The Massachusetts Ocean Management Task Force Report and Recommendations* (Volume 1), and the *Massachusetts Ocean Management Task Force Technical Report* (Volume 2).

Waves of Change (Volume 1) includes an introduction, descriptions of the theme areas (i.e., governance, management tools, scientific understanding, and public outreach) that the Task Force has addressed, six Principles for ocean management, fifteen Recommendations with justifications and implementation plans, and a conclusion.

This Technical Report (Volume 2) is a compendium of separate ocean resource briefings written by staff to the Task Force and includes chapters on the public trust doctrine in Massachusetts, a descriptive overview of traditional and emerging ocean uses, an overview of data trends and needs, a summary of state and federal regulatory authorities relating to ocean resources, and several appendices.

The development of *Waves of Change* required Task Force members to consider complex ocean policy questions. To complete the charge given to us by the Secretary, it was necessary to share our expertise and experience, as well as draw on those of others. This Technical Report compiles information accumulated by Task Force members and staff that was utilized by the Task Force in the process of developing Principles, evaluating the adequacy of existing legal and policy frameworks governing our ocean resources, and examining the information base necessary to make ocean management decisions.

DEVELOPING THE TECHNICAL REPORT

This volume is the work of the Ocean Management Task Force (OMTF), and moreover of the staff and other experts who supported the Task Force during its work. To carry out its effort, the Task Force divided itself into six Working Groups: Principles; Data Trends and Needs; Use Characterization; Policy; Framework Issues; and Outreach. The Task Force members and staff involved in each working group reviewed, discussed and analyzed a wide range of information provided in formal presentations and in briefing papers developed by agency staff and Working Group members. From this information base, the Task Force was able to develop its preliminary recommendations in December 2003, which were commented on by almost 300 public individuals and organizations at public meetings and in written submissions through February 13, 2004. Many of the presentations, meeting summaries, public comments and source materials that the Task Force utilized are found on the Task Force website (http://www.state.ma.us/czm/oceanmgtinitiative.htm).

This Technical Report summarizes information provided to the Policy/Frameworks, Data Trends and Needs, and Use Characterization Working Groups. It is provided in this volume to reveal the basis for many of the Task Force recommendations and to share the wealth of information that was developed to support this effort. The Task Force anticipates that this information will be valuable for many uses beyond its own work. The following section outlines the charge for the three working groups whose reference information is summarized in this report.

THE WORK GROUPS

Data Trends and Needs Working Group

The Data Trends and Needs Working Group (DTNWG), composed of academic and government scientists, resource managers and advocacy groups, was assigned the large task of describing the diversity of ocean resources in Massachusetts. The Working Group also identified influences of anthropogenic activities on the abundance and quality of certain resources. The goal of the DTNWG was to summarize ocean resources data, key trends and gaps in data; summarize ecologically and economically important trends; determine if relevant data is readily available for planning purposes; determine what data is needed to support ocean resource management purposes; and provide recommendations to OMTF to improve data collection, management, analyses and interpretation to facilitate ocean resources management.

To achieve this multi-faceted goal, technical reports were drafted, and present a range of information about human and natural resource issues relating to the state's oceans, as well as identify limitations of the current knowledge regarding ocean resources. The data presented, however, are by no means a comprehensive assessment of all ocean resources or a thorough assessment of existing data. The DTNWG described trends in human population, maritime economics, alteration of marine habitat and life (cumulative impacts), oceanography and weather patterns, living marine resources, estuarine and marine habitat, and sediment and water quality in the technical reports provided herein. These technical reports support the Scientific Understanding and Outreach Recommendations.

Use Characterization Working Group

The Use Characterization Working Group (UCWG) was created to help the OMTF examine human uses and activities in Massachusetts coastal waters; identify areas of multiple uses, as well as those of highest user conflict; develop narrative descriptions and visual representations that summarize these uses; and identify potential coastal and ocean use trends. The UCWG sought to identify human use trends and developed a descriptive overview of the ocean uses in the coastal regions of Massachusetts. This material provides the basis for the Use Characterization recommendation found in the Management Tools section of *Waves of Change*.

Policy/Framework Issues Working Groups

Mid-way through the Task Force process, the Policy Working Group and the Framework Issues Working Group merged to become the Policy/Frameworks Working Group. This working group examined the existing body of statutes, regulations, and policies relevant to ocean resources and identified gaps, inconsistencies, and overlaps. From there, the group developed a series of recommendations to strengthen the existing tools in light of changing ocean uses. In addition, this group developed a recommendation to fill one of the most evident gaps in the Commonwealths' ocean management – the lack of proactive planning. This Technical Report provides a summary of the existing tools used to manage ocean resources as well as some analysis of the weaknesses of those tools. In addition, this section provides a concise summary of the Public Trust Doctrine in Massachusetts. The Public Trust Doctrine is considered by the Task Force to be the cornerstone to its work.

FORMAT OF THE TECHNICAL REPORT

This report is divided into several substantive sections that provide an overview of the status and trends of resources and uses of the ocean, the existing ocean resource regulatory framework, major human-induced impacts to ocean resources, (including pollution, habitat destruction and degradation, overfishing and effects of fishing on habitat). Additionally, an appendix is attached to this Technical Report and includes a glossary, a schedule of Task Force meetings, a list of commenters to our preliminary recommendations and public informational meetings in December 2003, and a summary of the implementation plans of each recommendation, including those agencies that will be leading implementation efforts.

The following sections are included in this report:

Population and Economy – The demographics of the Massachusetts coastal zone and the contributions of maritime industries to Massachusetts economy are detailed. Thirty (+) years of human population data are summarized for coastal municipalities. An overview of maritime industries is presented to describe the status and recent changes in our ocean-based economy.

Characterization of Ocean Uses – Information on trends in uses of Massachusetts ocean and coastal areas is described here. The information collected by the Use Characterization Working Group, staff, and the public at the Task Force's Meeting with Interest Groups is listed in this section. Since changing trends in ocean use led to the formation of the Task Force, this analysis provided valuable perspective to the group.

Cumulative Impact – General human-induced and natural impacts to habitat are identified and described for Massachusetts. This section briefly explains cumulative impacts, describes major anthropogenic impacts and natural influences, lists some local examples of these impacts, shows the geographic location of key impacts, and presents emerging issues.

Oceanography, Weather Patterns and Climate Change – Major oceanographic features and weather patterns are discussed, and the status and consequences of climate change are described.

Living Marine Resources – The summary includes a description of fishery resources, commercial and recreational fish and shellfish landings, abundance of selected species, and invasive species. The summary is largely based on monitoring programs currently undertaken by state agencies.

Estuarine and Marine Habitat – Habitats are categorized as wetlands, seagrass, and seafloor, and major datasets were summarized to provide an overview of the status of these resources.

Sediment and Water Quality – Monitoring programs, major discharges, and the general requirements for monitoring activities are identified to provide an overview of the current state of water and sediment quality monitoring programs.

The Oceans as a Public Trust – An overview of the Public Trust Doctrine, a cornerstone of the Task Force's recommendations, is contained herein. This section describes its history, legal framework and requirements, and applications.

Policy – This section examines issues with the state regulatory system and how the state implements its delegation of authority from certain federal statutes. This summary intends to provide a quick review of the key statutes most likely to apply to large coastal projects, as well as the types of development projects that government agencies have consulted on or reviewed.

TRENDS IN THE DEMOGRAPHICS OF HUMAN POPULATION & THE MASSACHUSETTS MARINE ECONOMY

1. DEMOGRAPHICS OF HUMAN POPUATION TRENDS

Using the U.S. Census data from 1970 through 2000, we examined three decades of changes in the Massachusetts coastal population. In Massachusetts there are 78 coastal cities and towns located in nine counties and data are summarized for these municipalities. These represent what we mean by the "coastal population."

The Commonwealth's population, as a whole, grew by 11.6%, or by 659,927 people in the thirty-year time frame of 1970-2000. There was minimal growth (0.8%) in the first decade (1970-1980) but in the last two decades, population growth has increased to 4.9% and 5.5%, respectively. The population growth in all coastal communities basically mimicked overall state population increases, growing at slightly slower rates (11.0% in the thirty year period, and 0.3% in the 70s, 4.5% in the 80s, and 5.9% in the 90s).

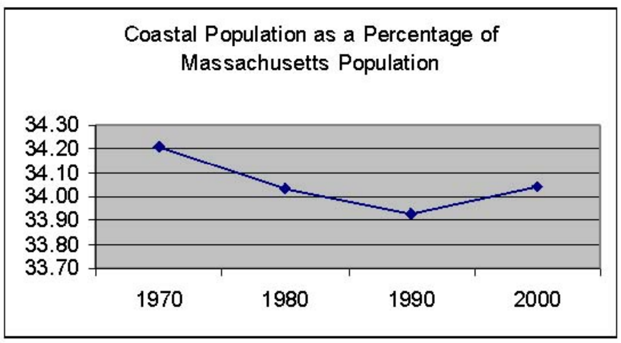


Figure 1. Coastal population percentage of total Massachusetts population.

In Massachusetts, the coastal community population in the year 2000 was a third of the total Massachusetts population over the last three decades this figure has remained constant. (Figure 1).

Table 1. Population change in coastal communities (number and percentage).

County	Population Change 1970-2000	Percent Change 1970-2000	Total 2000 population
Suffolk	-45383	-6.2	689,807
Plymouth	80633	56.9	222,430
Norfolk	-2606	-1.2	209,164
Nantucket	5746	152.2	9,520
Middlesex	-4448	-10.5	38,037
Essex	22467	5.6	420,364
Dukes	8870	145.0	14,987
Bristol	24318	7.8	335,003
Barnstable	125574	129.9	222,230
Total Coastal	215171	11.0	2,161,542
Massachusetts	659927	11.6	6,349,097

A more detailed picture emerges by examining the data on a coastal community-by-county basis. In Massachusetts there are nine coastal counties: Barnstable, Bristol, Dukes, Essex, Middlesex, Nantucket, Norfolk, Plymouth and Suffolk with these counties there are 78 coastal cities or towns. Barnstable (15 communities), Dukes (7 communities) Nantucket (1 community) and Suffolk (4 communities) Counties are entirely coastal counties. The remainder, Bristol, Essex, Middlesex, Norfolk and Plymouth, have 13, 19, 15 and 13 coastal communities respectively as defined by the Massachusetts Coastal Zone Management Plan. In the year 2000, the largest coastal county was Suffolk with 689,807 people and the smallest was Nantucket with 9,520 people. As shown in Table 1, the year 2000 populations of the other coastal counties fall somewhere in between.

In the last thirty years, Nantucket has had the highest growth percentage (152.2%), while Middlesex's coastal community has experienced a decreasing population of –10.5 % (Table 1). Many of the other coastal counties have had different growth experience relative to the average statewide growth of 11% over the 1970-2000 period: Suffolk – 6.2%; Plymouth 56.9%; Norfolk –1.2%; Essex 5.6%; Dukes 145.0%; Bristol 7.8%; and Barnstable 129.9%.

Examining the number of people gives a slightly different perspective (Table 1). Barnstable County grew by 125,574 people in the last thirty years, and Plymouth County's coastal communities grew by 80,633. Bristol County's coastal communities grew by 24,318 people and Essex County's coastal communities grew by 22,467. Duke and Nantucket Counties grew by 8,870 and 5,746 people, respectively. In the last thirty years, Suffolk, Norfolk and Middlesex Counties' coastal communities all lost population; 45,383; 2,606 and 4,448 respectively.

Table 2. Population change (number and %) by decade for coastal communities of Massachusetts.

County	Population Change 1970-1980	Percent Change 1970-1980	Population Change 1980-1990	Percent Change 1980-1990	Population Change 1990-2000	Percent Change 1990-2000
Suffolk	-85048	-11.57	13764	2.12	25901	3.90
Plymouth	43584	30.74	17041	9.19	20008	9.88
Norfolk	-2064	-0.97	-4037	-1.93	3495	1.70
Nantucket	1313	34.79	925	18.18	3508	58.35
Middlesex	-5290	-12.45	-1484	-3.99	2326	6.51
Essex	-12168	-3.06	11032	2.86	23603	5.95
Dukes	2825	46.18	2697	30.16	3348	28.77
Bristol	11813	3.80	10034	3.11	2471	0.74
Barnstable	51269	53.04	38665	26.14	35640	19.10
Total Coastal	6232	0.32	88637	4.54	120300	5.89
Massachusetts	47923	0.84	279332	4.87	332672	5.53

When population levels are examined by decade, even finer details can be seen (Table 2). From 1970-1980, the urban counties, Suffolk, Norfolk Middlesex and Essex, lost population. Number-wise and percentage-wise, the largest population growth along the coast occurred in Barnstable and Plymouth Counties (51,269, or 53.0%, and 43,584, or 30.7%, respectively). In the eighties, Middlesex and Norfolk lost population, the other counties grew with Dukes County leading the way percentage wise (30.2%) and Barnstable and Plymouth Counties leading the way numerically (38,665 and 17,041). In the nineties, all coastal counties experienced growth. Nantucket and Dukes Counties experiencing the most percentage wise 58.3% and 28.8 %, respectively. Numerically, Barnstable leads the coastal counties with a 35,640-person increase in population, Suffolk (25,901), Essex (23,603) and Plymouth (20,008) Counties' coastal communities all grew by over 20,000.

SUMMARY

Overall, the population of the Massachusetts coastal zone grew proportional to the Commonwealth's population - the relative percentage of people in coastal communities as compared to the state remained about the same over the last thirty years. In the seventies, the population migrated out of coastal urban areas into rural coastal communities of the Cape, Islands and Plymouth Counties. In the eighties, the migration trend out of urban counties slowed and stopped, but immigration into the rural coastal communities of the Cape, Islands and other coastal counties continued. The nineties saw population growth in urban coastal areas, and immigration into rural coastal communities continued. So while urban coastal populations decreased and then grew anew, rural coastal communities in all coastal communities saw three decades of growth.

LITERATURE CITED AND SUGGESTED READINGS

Massachusetts Institute for Social and Economic Research. www.umass.edu/miser

U.S. Department of Census Data. www.census.gov/population/cencounts/ma190090.txt

2. THE MASSACHUSETTS MARINE ECONOMY

This section describes the contribution of the maritime industries to the Massachusetts economy. The maritime economy in this state is constantly evolving, as it adapts to the changing demand for products and services and supply of natural resources. This overview provides a 'snap shot' of the current conditions in Massachusetts, in which there is a general transition away from extractive industries to tourism-services throughout Massachusetts. Sources for the statistics mentioned here are located at the end of this section.

A. The Workforce

The Massachusetts marine economy is responsible for approximately 81,808 jobs, or 2.5% of the state's workforce (Figure 2). Maritime businesses have contributed a notable value to the Massachusetts economy, and more significantly to coastal communities (Figures 3, 4 and 5). For these latter areas, there is a strong interest in preserving jobs in the maritime industries, because of both the direct and indirect effect of such on the local economies. These communities also have built an infrastructure base to support the marine-related industries in ways not found in other communities.

Unfortunately, these coastal locations also attract high residential and commercial property values, which are putting increasing pressure on these maritime uses. Residential and commercial development within coastal communities has consistently outgrown the rest of the state and will likely continue. With undeveloped or developable coastal land becoming more rare, developers are eager to find any opportunities that will allow them to utilize soaring coastal valuations. The possible permanent displacement of some maritime jobs and marine-related land uses in Massachusetts is a reality. Demand for maritime goods and services helps maintain maritime jobs, but zoning and port protection policies have prevented large-scale conversion of port infrastructure to other land use (e.g., residential). Despite the zoning and port protection policies, land use change may be possible in particular locations where local municipalities allow it.

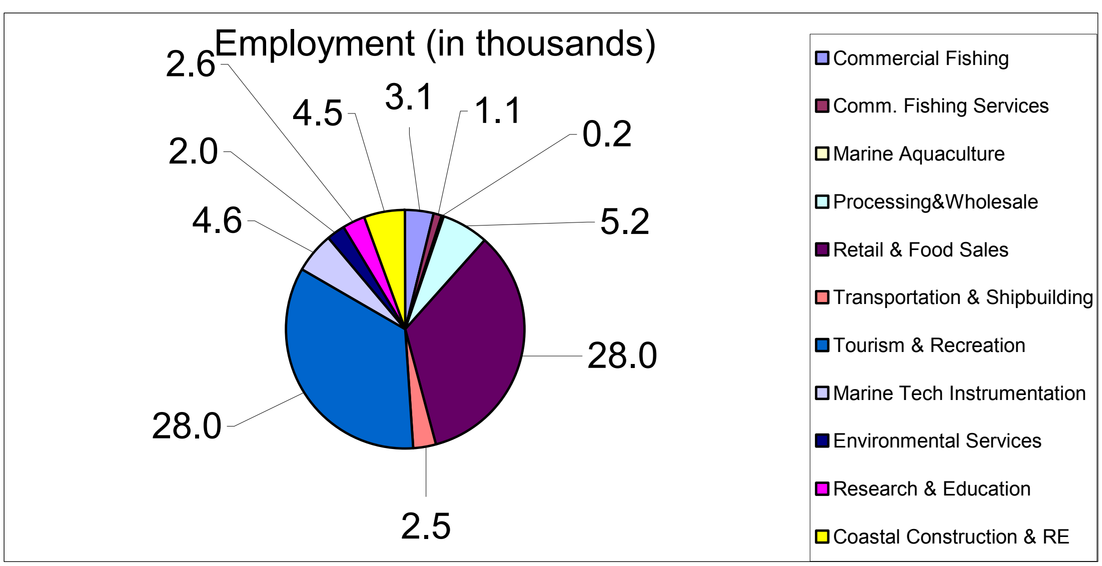


Figure 2. Contribution of maritime industries to the marine economic workforce.
Source: The Massachusetts Marine Economy, 1997.

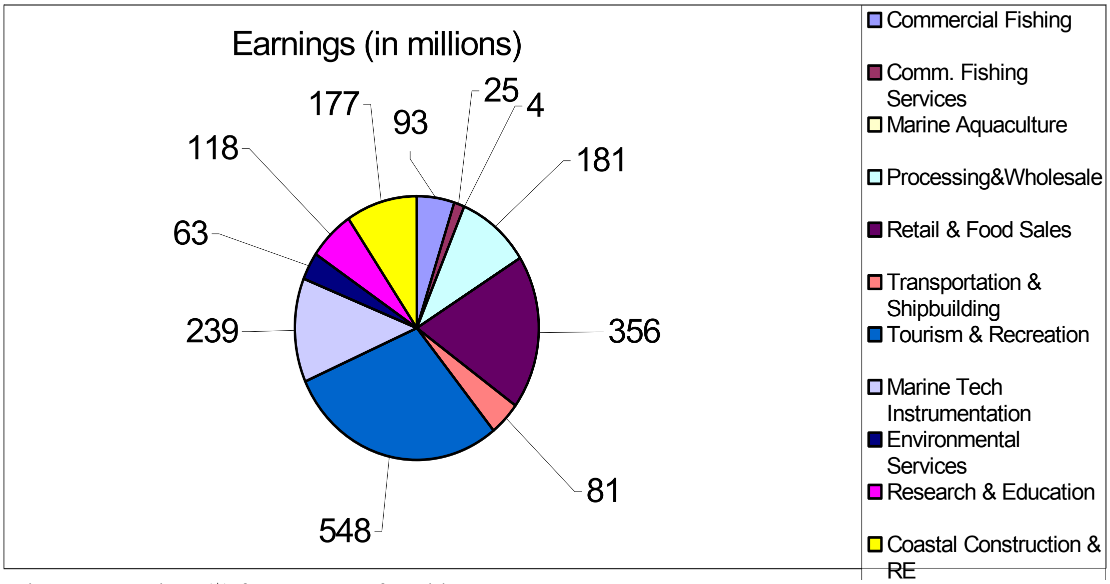


Figure 3. Earnings ($) from sectors of maritime economy.

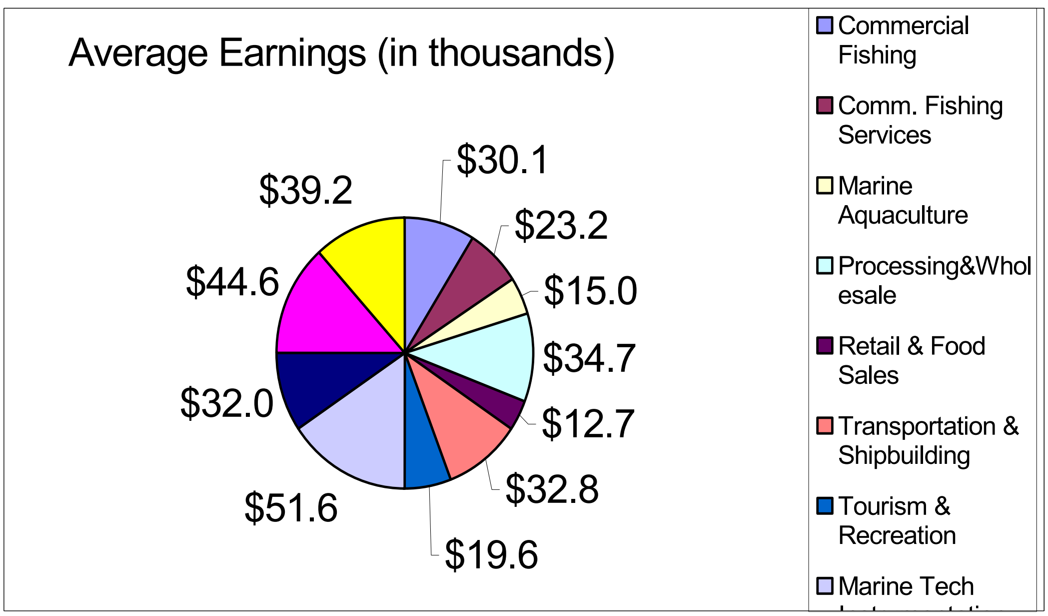


Figure 4. Average yearly earnings ($) from sectors of maritime economy.
Source: Massachusetts Marine Economy, 1997.

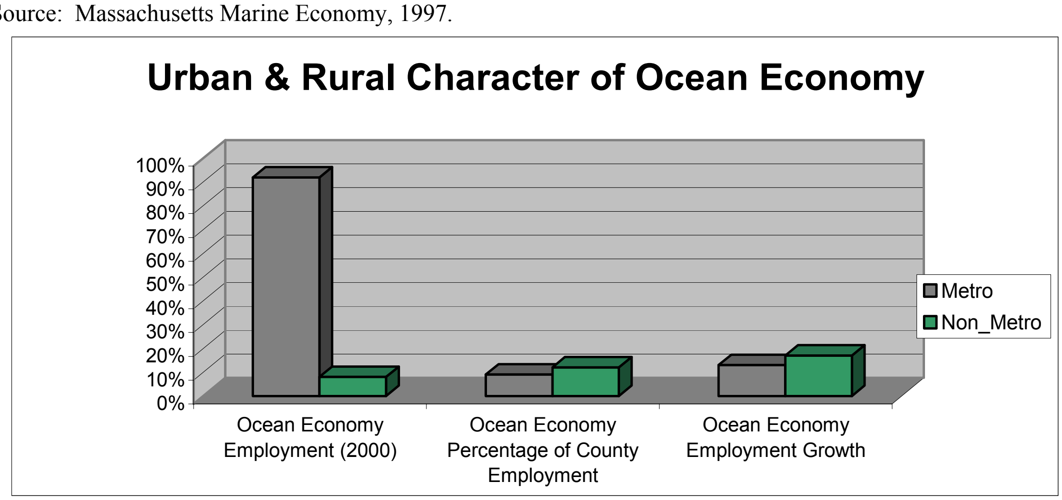


Figure 5. Contribution of urban and rural communities to maritime economy.
Source: The Changing Ocean and Coastal Economy of the United States, 2003.

B. Growth & Change

A dramatic reduction in shipbuilding and navigation equipment began in the early 1980s, caused by a number of factors, including the U.S. Navy's reduced demand for vessels after the end of the Cold War, and improvements in the productivity of the offshore oil and gas industry. Marine shipping efficiency and productivity has also increased through the industry's ability to meet cargo demands with fewer larger vessels. These operational improvements have subsequently resulted in a decline in the deep-sea freight handling industry.

Additionally, the U.S. ocean economy leaned away from extractive sectors, such as mineral production and commercial fishing, over the last decades and has instead illustrated its strong potential in the tourism industry (Figure 6).

This pattern has presented coastal states with an economic development challenge, as these growing service industries operate on relatively low average wages. The average wage for the recreation and tourism sector was $16,320, compared, for example, to the $60,000 + salary that the minerals sector provides[1]. This transition is part of a larger trend, where high- paying jobs, such as those in minerals, are being phased out and replaced by those in tourism and recreation. This change produces a change in the demand for traditional job skills in the marine industries, and a lower overall income and spending power in the local economy, and lower tax-related revenues. On the other hand, an increase in tourism may provide counter-vailing trends.

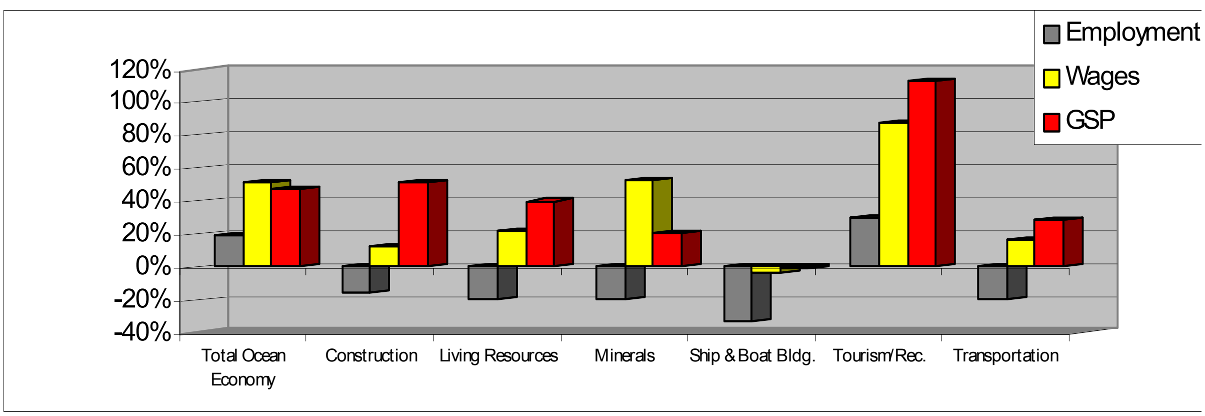


Figure 6. Changes in the ocean economy from 1990 – 2000.
Source: The Changing Ocean and Coastal economy of the United States

The transition from industrial to service industries, and the higher property values in coastal communities may also be increasing pressure on the development of more coastal lands. The potential transition of industries should be analyzed from a macroeconomic perspective to gauge the economic, social, and environmental impacts that a large-scale land use change will have on a coastline as a whole

[1] The Changing Ocean and Coastal Economy of the United States, 2003.

C. Transportation

In 2000, Marine transportation in Massachusetts, including freight and passenger transport, was responsible for the employment of approximately 2,500 people, with cumulative salaries of $81 million. Approximately one-six of this payroll comes from the transportation of passengers aboard commuter boats, taxi boats, etc. Another third of the entire payroll stems from freight transport. Out-of-state transport businesses involved in moving people to and from the Massachusetts coastline are not accounted for in these figures.

D. Tourism

Cape Cod and the Islands welcome 4.7 million domestic visitors, or 19% of all tourist visits to Massachusetts. This is the second most visited region in the state, behind Boston, and maintains a high level of attractiveness largely because of its coastal resources. Cape Cod is a region highly renowned for it's vacationing attractions, most notable of which are the beaches and bays. Approximately 48% of visitors participate in beach going while visiting Cape Cod, compared to 40% who participate in. 9.8% of domestic tourists who come to Massachusetts visit the beaches.

E. Recreation

Recreation statistics reveal that Massachusetts citizens highly appreciate and value coastal resources. Out of the 24 coastal states for which comparable survey data are available, Massachusetts ranked 9th in the level of participation in various coastal activities[2]. In terms of the population, 46% of Massachusetts residents, or 2,928,767 participants, visited the coast in 1999. The activities below are a few in which Massachusetts appears to value highly in comparison to other coastal states.

- 34% participation rate in coastal viewing - 2,143,198 only behind California and Florida **3rd/24**
- 3% participation rate in coastal diving - 161,768 **6th/24**
- 19% participation rate in boating - 1,224,969 **6th/24**
- 44% participation rate in diving/swimming - 2,750,203 **8th/24**

A special Massachusetts coastal recreational activity is whale watching, which substantially expanded in past decade throughout the state. The Plymouth and Provincetown coastline has long been used for whale watching operations. In 1996, this industry drew in $21 million in revenue and supports a market for surrounding businesses.

Overall in Massachusetts, there were 30,741 employees in tourism, recreation and transportation, which is 34% of the total marine economy. Coastal tourism supported 23,500 jobs with a payroll of $400 million[3]. Additionally, recreational boaters spent $300 million in 1996 in total boating expenditures[4].

[2] National Survey on Recreation and the Environment, 2000.
[3] Massachusetts Travel Industry Report, 2003.
[4] Massachusetts Marine Economy, 1997.

F. Recreational Fishing

Over the past ten years, the state's recreational fishing industry has expanded enormously, and is now ranked as the second most valuable in the United States. The striped bass recreational fishery is widely regarded as the finest in the country, and draws participants from all over the country. Marine recreational anglers in Massachusetts spent about $850 million pursuing their sport in 1998[5]. Over 900,000 people participated in the marine recreational fishery in 2002, including 560,000 of the Commonwealth's citizens[6]

G. Commercial Fisheries

The Commonwealth of Massachusetts has long supported one of the most valuable commercial fishing industries in the nation. In terms of revenue, the most lucrative fisheries in Massachusetts are scallops, lobster and lastly a variety of groundfish. Together, the commercial and recreational marine economies employ more than 80,000 people in Massachusetts, 40,000 from the seafood industry alone, and contribute close to $2 billion to the economy. This figure includes $659 million in fishing and sales, and $132 million in fishing and support services (e.g., fuel, ice, bait, food, insurance, and mortgage).

In recent decades, the Massachusetts economy has suffered from the combined effects of decreasing fish stocks and fishery restrictions. With the current situation of sparse fisheries, most ports have felt the harsh economic realities over the recent downturn. Ports such as Gloucester, where commercial fishing is the primary operation, were affected the hardest. The changes in the commercial fishing industry affect participating businesses, and this tends to increase the pressure to change the economic base of the community to make it less dependent upon fisheries-related activities and to diversify land use to accommodate supporting sources of income, change operations, or potentially sell land to a more profitable business.

The National Marine Fisheries Service is still in the early stages of much of its research to provide complete profiles for all US fishing-dependent communities in formats to allow easy comparisons across communities and regions. A number of studies and workshops have been proposed or are underway at the present time. Few final reports are as yet available -- especially with regard to social and cultural aspects of communities.
http://www.st.nmfs.gov/st1/econ/cia/data_collection.html

H. Aquaculture

The aquaculture industry is responsible for less than 3% of the seafood catch in Massachusetts. The industry is dependent upon hard shell clams and American oysters, while soft-shell "steamer" clam, razor clam, bay scallop, sea scallop, surf clam and blue mussel are gathered to meet a smaller demand. While compared to other states, the Massachusetts aquaculture industry is small, its value in 2002 was $3.6 million, producing an impact of $16 million on the state economy (Figure 7). Nearly four-fifths of the aquaculture industry's cultivation is located on

[5] Steinbeck & Gertner, 2001.
[6] Armstrong, personal communication from National Marine Fisheries Service.

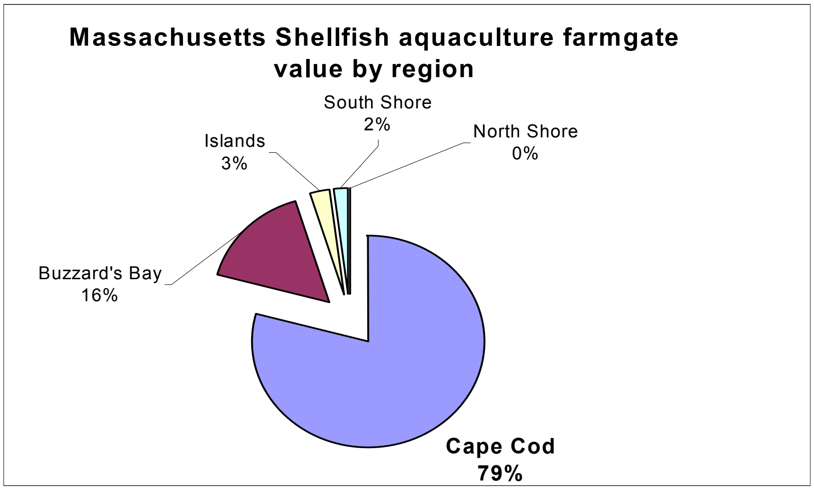
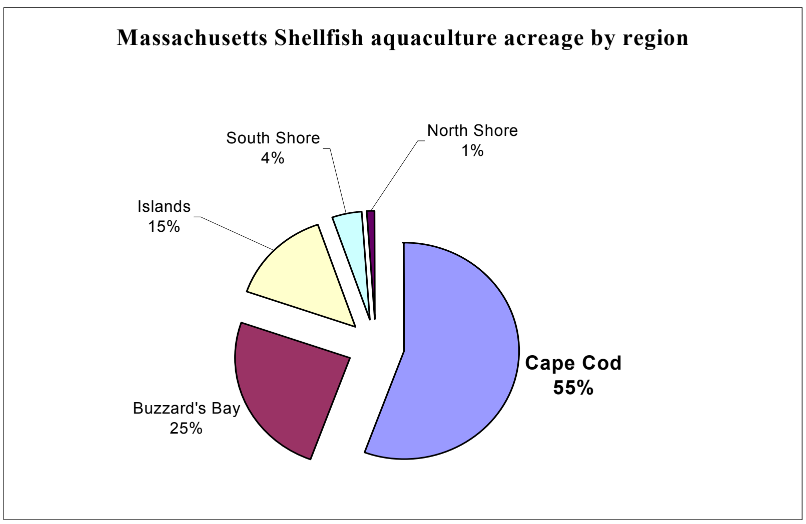
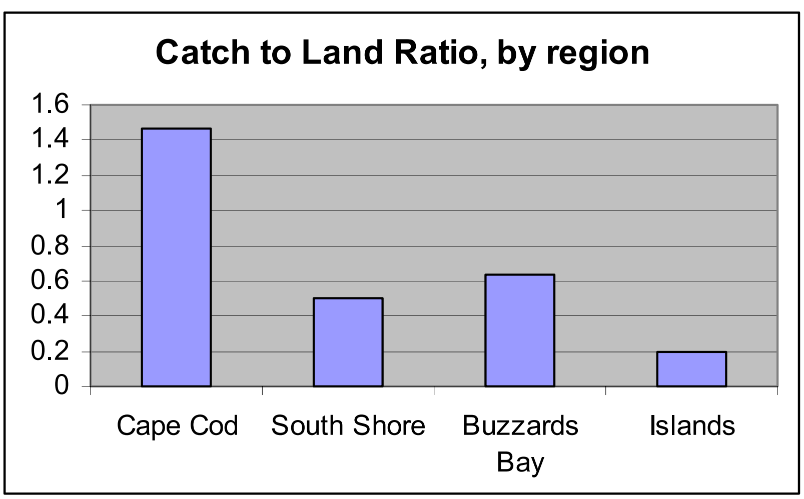


Figure 7. Regional contribution to aquaculture production.

Cape Cod, with the Buzzards Bay, Islands, South Shore, and North Shore culture being proportionately smaller than their harvestable area allows (Figure 8). The South Shore and North Shore regions have experienced the most growth over the past five years. Overall, the Massachusetts aquaculture industry sits third in size in New England behind Maine ($90 million market) and Connecticut ($13.2 million market).





I. Marine Technology

Marine Technology in Massachusetts, (including marine instrumentation, environmental services and research), is estimated to have employed 9,420 people, who earned $420 million, in 1997. Marine technology is applied in projects like mapping, monitoring weather and environmental quality and surveying for oil and gas deposits. Users of marine technology are quite expansive, including commercial fishing, maritime transportation and shipbuilding, marine environmental services, research and education[7].

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CHARACTERIZATION OF OCEAN USES

Summary

Massachusetts coastal waters accommodate a wide variety of uses that are often separated by time of day, seasons of the year, location (i.e., sea floor bottom, water column, water surface, air), or existing "zones" to accommodate specific use areas (*e.g.*, shipping lanes). Given the high use levels in our waters, actual use conflicts in Massachusetts are relatively limited. However, an increase in overall level of use, the development of new types of coastal and ocean activities, and a loss of productive maritime and estuarine habitat will likely lead to a significant increase in user conflicts.

Information on historical and up-to-date inventories of the uses and resources of the state's marine waters has not always been readily available, and should be, in order to support ocean management planning and to identify trends in human maritime activities. These inventories should be GIS-based and:

- illustrate uses and resources on the seafloor, in the water column, at or above the ocean surface, and in the air space above the ocean;
- indicate when human and natural activities and events occur over time; and
- incorporate relevant upstream and offshore areas that affect coastal resources.

Successful management of human activities in the near-shore environment must be based on a sound knowledge of those activities and the sustainability of the resources they impact. For this reason, information on natural resources and human activities should be developed in a format that allows for easy overlays and comparison of information.

Background

As part of the Ocean Management Task Force's efforts, the Use Characterization Working Group (UCWG) was created to help:

1) examine human uses and activities in Massachusetts coastal waters;
2) identify areas of multiple uses, as well as those of highest user conflict;
3) develop narrative descriptions and visual representations that summarize these uses; and
4) identify potential coastal and ocean use trends.

The UCWG relied for the most part on existing data. Many data sets for water quality conditions, natural resource characteristics, political and regulatory jurisdictions, and stationary structures are already available through the Massachusetts Ocean Resource Information System (MORIS), and other GIS-based programs. MORIS is a comprehensive database providing access to the broad range of information necessary to manage coastal and ocean resources. An ArcView-based application provides easy access to the MORIS dataset, which currently houses over 200 layers. This application and the MORIS datasets are currently distributed free on CD-ROM, but will be available for download and display on the MassGIS on-line mapping site in late 2004, making it highly accessible to the general public.

The UCWG developed preliminary use characterizations and narratives based on these data to help guide the OMTF in drafting preliminary recommendations. The initial efforts, using static drawings that depicted various uses of coastal waters in different regions of the state, were helpful in providing the Task Force with very general use characterizations, but lacked specificity with regard to location of uses, seasonality of activities, and cross-sectional uses that may extend from the sea floor to the air space above the ocean surface. Problems were also identified in graphically representing widespread uses, such as recreational boating and lobster fishing, where a GIS-based application or narrative description would provide more clarity. From this effort, it became clear that there was a need to collect, inventory, house, update, and manage information on uses and activities in coastal waters, and develop accessible methods to display and interpret complex use characterizations to ocean managers and the general public. Based on feedback from the OMTF and the public, rough-cut coastal and ocean use characterizations have been useful to the OMTF to get a sense of what's going on where, but the real value of use characterizations is as a long-term management and educational tool for resource managers and the public. Accordingly, the OMTF has adopted a recommendation that the Commonwealth develop comprehensive, GIS-based use characterizations that will be updated on a regular basis.

The UCWG sought to identify human use trends and developed its own list of trends, which was supplemented by additional public comments. However, the UCWG received several recommendations to develop historical use characterizations, which could then be used to identify trends in a more empirical fashion rather than rely on time-specific observations and anecdotal information. Developing historical use characterizations are part of the Use Characterization Recommendation in Management Tools and are included to assist in the identification of human use trends over time for decision-makers and the public.

The UCWG's initial use characterization, describing the types of activities and general physical characteristics in each of five Massachusetts coastal regions, appears in this chapter. The Use Characterization Recommendation in Management Tools outlines the steps needed to more fully develop use characterizations and present relevant information in a clear, accessible format for use by ocean managers and the public.

The UCWG was chaired by Tom Skinner and staffed by Deerin Babb-Brott. Other UCWG members included Bill Adler, Dale Brown, Tom Cox, Rip Cunningham, Robbin Peach, Tim Smith, and Tim Timmermann. Vin Malkoski, Tony Wilbur, Steve Mague, Diane Carle, Todd Callaghan, Andrea Cooper, Jason Burtner, Truman Henson, and Dave Janik participated from state environmental agencies.

Methodology for Developing Characterizations of Uses in Different Regions of the State's Oceans

There is currently no comprehensive database identifying the type, spatial and temporal qualities, and geographic locations of the myriad activities that take place along the Massachusetts coast. To assist the Task Force in the development of its draft preliminary recommendations, the UCWG developed a rough geographic representation of coastal and ocean uses, based on personal knowledge of staff from the Massachusetts DMF and the Massachusetts Office of CZM. Given the significant limitations of the static geographic representations, a narrative was developed in which the natural, industrial, recreational, commercial, and other characteristics or uses were generally described for each of five coastal regions.

Although the narrative and the geographic representations are included in this chapter, it is important to understand that both products were developed specifically as illustrative representations to provide the Task Force with a working sense of the uses and resources that characterize the several geographic regions within Massachusetts state waters. They were presented to the Task Force to generally describe and illustrate the industrial, commercial, recreational, natural, and other (*e.g.,* military/homeland security and cultural) coastal features.

Initially, the UCWG had to determine the scope of its work and whether land, harbor or shoreline-based uses or resources within each of the categories should be included, and, if so, how they should be represented. For example, individual marine-related facilities within a harbor, upland areas within a coastal watershed that contribute significant non-point runoff, local shellfish beds, and inshore areas frequented by recreational fishers were all considered for inclusion in the use characterization.

The determining issue in these deliberations was the Task Force's purpose to recommend an overall ocean management strategy, and not to develop actual information-based management plans – at least at this point in time. In this regard, the UCWG imposed basic assumptions on our product and recommendations to help focus on uses and resources of the ocean proper, resulting in the following general approach:

- The maps focus on the major features that directly occupy or have a major effect on the ocean, as opposed to harbors and small embayments.
- Specifics on the most common or predominant coastal features are not included because most of these features are located at the terrestrial margin. Rather, the information forms the basis for the textual characterization of the regions. Terrestrial features are mapped where they are highly determinative of the use or character of the region, like the Great Marsh on the North Shore, or the National Seashore on Cape Cod.
- Industrial, commercial and recreational uses of ports and harbors are illustrated, with greater emphasis indicated for areas of intense use; note that some level of recreational and commercial boating use is associated with every harbor and inlet coast-wide.
- With the notable exception of the lobster fishery, which tends to occur almost everywhere along the Massachusetts coast, the information on fisheries is presented not to illustrate for planning purposes what is fished for where, but as an illustration of the fact that, while fishing may be said to occur "everywhere," there are generally identifiable areas of higher recreational and commercial effort, based on bathymetry, surficial geology/habitat, or the seasonal presence of a given species. We have illustrated some of that in these characterizations. For future management plans, information from recreational and commercial fishing sources can be overlaid to compile a detailed use characterization.

Once our assumptions have been applied, there are not a lot of human constructions to map. The primary uses of our ocean waters include industrial intake and discharge of seawater, cables and pipelines, industrial vessel navigation (in narrowly geographically defined areas), recreational and commercial boating and fishing (over broad and geographically diverse areas) and intertidal/shallow water shellfish aquaculture.

Regional Use Characterizations

The initial use characterization developed for the Task Force included both a narrative and graphic, static representations of existing uses along the Massachusetts coast. Some uses, such as shipping channels and industrial port facilities, were clearly shown on the graphic representations, which used NOAA charts for base-line information. Other types of information, such as ports for commercial or charter-boat fishing, or areas of higher-than-normal recreational boating activity, were easier to describe in the narrative section. In this report, we have included one coast-wide use characterization graphic representation, the narrative description, and an example of a MORIS natural features map, illustrating how use characterization information could be displayed in a GIS-based format.

NORTH SHORE (SALISBURY TO NAHANT)

North Shore: Summary

The North Shore features major commercial and recreational boating and fishing uses, including a growing ecotourism industry. There are two ports with significant industrial features. Generally, the coastline is open to the ocean and marine uses are concentrated in near-shore waters. From Cape Ann to the south, the seafloor is characterized by major areas of hard bottom and relief with a major lobster fishery; north of Cape Ann the seafloor is predominantly sand and flat bottom sloping up to a significant barrier beach/saltmarsh system. The Annisquam River is a major ocean use feature for commercial and recreational boats.

North Shore: Natural Resource Characteristics

North of Cape Ann is generally a sand and flat bottom coast with a significant barrier beach/saltmarsh system, which serves as a stopover on the Atlantic Flyway for migratory birds. South of Cape Ann is characterized by hard bottom and relief. The Great Marsh across the Essex Bay and Plum Island Sound regions comprises over 25,000 acres of beach/marsh habitat and defines the regional coastal character; it is designated by the state as an Area of Critical Environmental Concern (ACEC). The Merrimack River is a major run for diadromous fish and contains populations of endangered fish species. Jeffries Ledge is a major geographic feature targeted by commercial and recreational fishers and boaters. Whales and other marine mammals frequent North Shore waters. The water quality is good outside of harbors and embayments, but enclosed and/or populated areas typically experience some impairment of water quality in the immediate vicinity of sewage outfalls and, more broadly following periods of significant rain, leading to temporary closures of shellfish beds.

North Shore: Industrial Characteristics

In general, only Gloucester and Salem are hubs of industrial activity in the North Shore area of the state's oceans. Each port has industrial shipping activity supported by major federal navigation channels. There is a transitway offshore and parallel to the coast for ships crossing the Gulf of Maine. Outfalls are located along the coast (Newburyport, Ipswich, Rockport, Gloucester, Manchester, Salem, and Swampscott). Salisbury to Gloucester is characterized by a lack of industrial features other than outfalls. The Merrimack River carries industrial effluent, including treated sewage and industrial process water.

North Shore: Commercial Characteristics

Commercial fishing (all kinds, including charters, party boats, etc.) and boating (whale watching, kayak tours) is practiced extensively in the nearshore waters. The Merrimack River, Cape Ann, and Salem Sound areas are homeport to significant commercial fleets. Commercial vessels use the Annisquam River heavily. Essex Bay and Plum Island Sound are areas of significant commercial use by ecotourism businesses. While lobster potting occurs in virtually all near-shore waters, it is generally concentrated within the 120-foot depth line. Roughly 13% of the total state lobster catch occurs in the waters between Nahant and Manchester and 15% of the total between Gloucester and Rockport, the two most productively fished areas. Dragging, gillnetting and lobster potting occur from Eastern Point south through Massachusetts Bay; dragging and scallop dredging occur in Ipswich Bay.

North Shore: Recreational Characteristics

Recreational boating occurs throughout the North Shore waters, and every harbor and port supports some level of boating activity. The Merrimack River, Plum Island Sound, Essex Bay, Cape Ann, and Salem Sound are major hubs of recreational activity. The Annisquam River/Blynman Canal is a major recreational feature that connects Ipswich Bay and Massachusetts Bay. Recreational boating destinations include nearshore fishing locations, all of Cape Ann for diving, and Stellwagen Bank. The Great Marsh across the Essex Bay and Plum Island Sound regions is a major recreational destination. North of Cape Ann is characterized by public beaches of regional and national significance.

North Shore: Military, Cultural, & Other Characteristics

The Coast Guard has stations in Newburyport and Gloucester. There are U.S. Navy submarine routes off the North Shore up to Portsmouth, NH, and the Gulf of Maine area.

MASSACHUSETTS BAY (METRO BOSTON AREA; NAHANT TO COHASSET)

Massachusetts Bay: Summary

A key feature of Massachusetts Bay is its breadth and the great diversity of uses over, on, and beneath the waters. Boston is the regional maritime industrial and commercial hub, and the uses centered around the port dominate the waters. Planes using Logan Airport approach and depart over Massachusetts Bay and sewage from metropolitan Boston communities is treated at Deer Island and pumped through a tunnel nine miles offshore. Major shipping lanes and anchorages and a dredged material disposal site in federal waters support major commercial and industrial vessel traffic. The Boston Harbor Islands are a nearshore natural and recreational area, and the Stellwagen Bank National Marine Sanctuary is a major offshore natural, recreational, and commercial area. Nearshore waters offer major opportunities for recreational diving and support the state's greatest concentration of lobster potting; offshore waters support dragging, gillnetting, charter and party boat fishing, and recreational fishing. Whales and other marine mammals frequent Massachusetts Bay waters. Massachusetts Bay is defined by a baseline of the territorial sea, drawn from Eastern Point in Gloucester to Strawberry Point in Cohasset; state waters extend three miles seaward of the baseline. Under this delineation, a significant portion of the Bay lies outside municipal boundaries but within state waters.

Massachusetts Bay: Natural Resource Characteristics

Massachusetts Bay has diverse surficial geology. The nearshore waters of Massachusetts Bay are characterized by hard bottom and relief, including islands and submerged and intertidal ledges. Areas of gravel and cobble have been identified as significant habitat for juvenile lobster. To the north, Broad Sound, enclosed by the rocky headlands of Nahant and Winthrop, is a generally sandy embayment that slopes up to a major beach area backed by an extensive saltmarsh system designated by the state as an ACEC. To the south, the sand and cobble beaches and nearshore waters off Hull give way to the bold shore and rocky bottom of Cohasset. The offshore seafloor is a mix of hard bottom (sand/gravel/cobble/boulder/ledge) out to the soft bottom areas from south of Cape Ann, through Stellwagen Basin, down into Cape Cod Bay. Stellwagen Bank, a National Marine Sanctuary, is a major offshore natural feature of local, regional, and national significance. Several species of whales and other marine mammals frequent Massachusetts Bay waters, including, notably, endangered Humpback and Northern Right Whales; Stellwagen and bordering waters are major feeding grounds. The new Massachusetts Water Resources Authority (MWRA) treatment plant has significantly improved nearshore water quality; monitoring of Massachusetts Bay water quality does not appear to show significant adverse impacts; the potential for chronic impacts continue to be studied.

Massachusetts Bay: Industrial Characteristics

Boston Harbor is a major maritime industrial port. Shipping is a major use of Massachusetts Bay waters; the major shipping lanes run from Boston outer harbor to the southeast off of Provincetown. Ships carrying products such as petroleum products, liquefied natural gas, automobiles, scrap metal, other manufactured goods, and cruise passengers pass in and out of Boston daily. Several power plants, manufacturers (Gillette, for example), and businesses (Hook Lobster Co., for example) use seawater from the harbor. The Conley container terminal, the complex of uses on the Mystic River, Logan Airport, and Chelsea Creek are major industrial features. The Fore River Shipyard (whose use is discontinued) in Quincy and Weymouth Back River (gas pipeline and ships carrying petroleum products) are areas of localized industrial activity. The MWRA outfall discharges treated municipal sewage from the metro-Boston area nine miles out into Massachusetts Bay. Lynn and Hull have municipal outfalls. The Saugus

River supports the General Electric jet engine plant and the Refuse Energy Systems Company (RESCO) trash to energy facility, both of which draw water from and discharge back into the river. A tidal power desalinization plant has been proposed off Hull. Massachusetts Bay waters were used historically for dumping industrial waste, including low-level radioactive waste, and dredged material. The Massachusetts Bay Disposal Site, a federally designated disposal site for dredged material, is located just outside state waters on the edge of the Stellwagen sanctuary; historic dumping grounds are noted on NOAA charts and include two prominent areas, the Boston Lightship site and the Industrial Waste Site (IWS).

Massachusetts Bay: Commercial Characteristics

Massachusetts Bay also supports a major concentration of commercial uses; while most of Massachusetts Bay supports some level of commercial activity, the intensity of use is greatest from the waters around the Boston Harbor Islands landward. Fishing of all types, dive charters, and passenger ferries frequent these nearshore waters. Offshore, Stellwagen and neighboring waters support whale watching and charter and party boats. There are major recreational marinas in Lynn, Revere, Boston, Quincy, Weymouth, Hingham and Hull. A gambling boat departs from Lynn. Major commercial routes crisscross the Bay connecting the Cape Cod Canal, Boston Harbor, the Annisquam River, and Provincetown/Stellwagen Bank. Massachusetts Bay is heavily used for commercial fishing, and supports a major lobster fishery (28% of the state's total catch), groundfish dragging, gillnetting, and charter and party boats. Generally, dragging occurs where the bottom is flat and open; other gear is used on areas of greater relief.

Massachusetts Bay: Recreational Characteristics

Massachusetts Bay is a major recreational area and boating occurs throughout the waters. Major destinations include Stellwagen Bank for fishing and whale watching, and the Harbor Islands for boating, hiking, fishing, and diving. Recreational fishing and diving occur at numerous nearshore areas. Major recreational routes connect the Cape Cod Canal, Boston Harbor, the Annisquam River, Provincetown/Stellwagen Bank, and smaller ports in between.

Massachusetts Bay: Military, Cultural, & Other Characteristics

The U.S. Coast Guard has stations in Hull and Boston. Military vessels from the U.S. Navy and other countries visit Boston occasionally; some repair/service facilities for military vessels are available.

SOUTH SHORE AND CAPE COD BAY (SCITUATE TO PROVINCETOWN)

South Shore and Cape Cod Bay: Summary

Compared to Massachusetts Bay, Cape Cod Bay has a lower but still significant intensity of uses. Primary features include its largely sand and cobble composition and shallow waters; the Cape Cod Canal, which is a major industrial, commercial and recreational feature; and the harbors of Marshfield, Scituate, Duxbury, Plymouth, Barnstable, Wellfleet, and Provincetown, which support substantial recreational and commercial fleets. Recreational use is high. Much of Cape Cod Bay is a seasonal feeding ground for the endangered Northern Right Whale. Industrial use is relatively low, and includes shipping, municipal sewage outfalls, and two power plants.

South Shore and Cape Cod Bay: Natural Characteristics

The South Shore coastline from Scituate to Plymouth is predominantly sand and cobble beaches, the product of the region's geology and exposure to seas from the east and northeast, which typically experience significant coastal erosion during storm events. Nearshore gravel and cobble beds support juvenile lobster. Cape Cod Bay itself is more protected and less dynamic; it is a relatively shallow, flat embayment characterized by sandy/silty sediments, sandier to the northwest and siltier to the southeast. Billingsgate Shoal, off Wellfleet, is the major submarine feature and forage ground for gamefish. (The great white shark in the Smithsonian was caught on Billingsgate.) Cape Cod Bay is designated critical habitat for the Northern Right Whale, which typically inhabit the waters during winter and early spring months, although individual whales may periodically stay on later in the year. Humpbacks, other species of whales, other marine mammals, and turtles frequent the waters. Mass strandings of lesser whales and turtles is a relatively common occurrence on the eastern coast of the bay. Water moves through Cape Cod Bay in a generally counter-clockwise circular pattern, entering from the north along the west coast of the bay, circulating south, east, and north following the perimeter of the bay, and exiting off Provincetown. The water quality is generally good and locally excellent (*e.g.,* Wellfleet Harbor is designated as a body of Outstanding Resource Water); however, in some areas, rain events flush septage from nearshore leach fields and cause temporary and localized closures of shellfish beds.

South Shore and Cape Cod Bay: Industrial Characteristics

There are relatively few industrial uses on the South Shore and in Cape Cod Bay. Scituate, Marshfield and Plymouth have sewage outfalls. The water-cooled Pilgrim Station nuclear power plant is located in Plymouth and the power plant in Sandwich along the Cape Cod Canal are the only major industrial facilities. The Canal supports small and medium sized industrial ship traffic to and from Boston and points north; tugs and barges carrying petroleum products represent the majority of the industrial traffic, which runs parallel up the western coast of the bay to Boston. Occasional cruise ships call at Provincetown. The Cape Cod Disposal Site, a state-designated site for dredged material, is located in state waters off Wellfleet. Designated in 1994, the site has been used by municipal and private facilities in Duxbury, Plymouth, Wellfleet, and Provincetown. The site is closed from January to mid-May to avoid impacts with Northern Right Whales.

South Shore and Cape Cod Bay: Commercial Characteristics

Commercial boating is a major use of south coast and Cape Cod Bay waters. Lobster potting is a major use – south shore waters account for 18% of state total lobster catch; the open waters of the bay and the southern and eastern nearshore account for another 13%. Groundfish dragging and localized scallop dredging occur in the bay and there is significant fishing for tuna, bluefish, and striped bass. The harbors of Marshfield, Scituate, Duxbury, Plymouth, Barnstable, Wellfleet, and Provincetown support major commercial fleets; Additionally, Rock Harbor in Orleans is home to one of the biggest charter fishing fleets in the northeast. All harbors and inlets support some level of commercial fishing activity. Shellfish aquaculture is a major nearshore (intertidal) commercial use, particularly along the eastern shoreline (*e.g.,* Provincetown and Wellfleet).

South Shore and Cape Cod Bay: Recreational Characteristics

Fishing, diving, and sailing are major uses of South Shore and bay waters. The harbors described above under "Commercial Characteristics" also support major recreational fleets. The beach and nearshore areas along the entire periphery of the region are heavily used for swimming, boating, kayaking, strolling and fishing. Billingsgate Shoal is a major recreational destination. Recreational diving for lobster occurs from Scituate to Barnstable. Off-road vehicle use is heavy in Plymouth and along the outer cape beaches and flats.

South Shore and Cape Cod Bay: Military, Cultural, & Other Characteristics

The U.S. Coast Guard has a station in Provincetown. The U.S. Navy periodically conducts small fleet maneuvers in the waters between the Cape Cod Canal and Massachusetts Bay off Boston Harbor.

CAPE COD AND THE ISLANDS (EASTERN AND SOUTHERN WATERS OFF CAPE COD, AND ALL WATERS OFF MARTHA'S VINEYARD, NANTUCKET AND THE ELIZABETH ISLANDS)

Cape Cod and the Islands: Summary

The Cape Cod and Islands region is characterized by dynamic sediment systems and locally by high-energy wave formations that impact both the landforms and the near shore bathymetry. These features, in conjunction with the many small harbors, estuaries and barrier beaches, have helped shape the historical and cultural foundation of the region. Fishing, yachting and other waterfront activities, together with the need to provide critical resources and services to the people of Nantucket, Martha's Vineyard, and the Elizabeth Islands have also shaped shorefront development in this region and the uses of the waters surrounding it. Finally, the entire region is largely dependant on tourism and therefore on the accommodation of recreational activities and the environmental conditions necessary for the support of that economy.

Cape Cod and the Islands: Natural Characteristics

The coasts of Cape Cod and the Islands are characterized by sandy barrier beaches backed by coastal dunes and coastal banks along much of the coast. There are dozens of coastal embayments and estuarine harbors scattered along the coasts as well. The surrounding waters vary from the very shallow depths of Nantucket Sound and the Nantucket Shoals, to the deeper waters of Cape Cod Bay and Vineyard Sound, to the ocean depths immediately off the eastern shore of Cape Cod. To the east of Cape Cod, the bathymetry quickly reaches to depths of one hundred feet and more, with the area subject to significant unimpeded wave energy, whereas the shallower and more protected waters are much more quiescent by comparison. There are thousands of acres of salt marsh and the area is significant to several endangered species of birds and vegetation. The Cape Cod National Seashore boundary includes portions of six of the outer cape towns, and the Cape is also home to the Mashpee and Monomoy National Wildlife Refuges. State-designated Ocean Sanctuaries encompass most of the state waters surrounding the region.

Cape Cod and the Islands: Industrial Characteristics

The industrial uses of the area are primarily related to fuel transport and storage. There are tank facilities located in Vineyard Haven Harbor on Martha's Vineyard and on Nantucket. Fuel is transported by barge to both of these facilities in significant quantities. Cruise ships, generally small coastal packets, call at Martha's Vineyard and Nantucket. There are also industrial transport activities associated with the year-round ferry service to the islands from Hyannis and Woods Hole.

Cape Cod and the Islands: Commercial Characteristics

Commercial fishing takes place with varying intensity in many of the harbors across the Cape and the Islands. While many smaller day trip boats dock at harbors such as Hyannis, Oak Bluffs and Menemsha, the most significant efforts take place from Aunt Lydia's Cove and Stage Harbor in Chatham, and from MacMillan Pier in Provincetown. Fisheries include lobster potting, fish, scallop and quahog dragging and commercial scale tuna and other finfish efforts. Hyannis, Falmouth, Menemsha, Oak Bluffs and Nantucket host large charter fishing fleets. Additionally, whale watching and eco-tourism operations embark from several harbors in the region.

Cape Cod and the Islands: Recreational Characteristics

Recreational boating popularity has exploded throughout the region during the past decade. This has caused significant burden and management challenges for those charged with the oversight of these activities. As evidence of the importance of this pastime, there are over fifty boat yards and other boat service facilities located on the Cape and Islands. Notwithstanding the long history of yachting around the area, it has gained even more popularity with economic growth of the region and is now of a greater magnitude than ever. Two particular concerns associated with this growth are the inherent conflict between this use and the other traditional and current uses of the area, and also the struggle to accommodate these numbers of boats along with their attendant supporting infrastructure, such as moorings, slips, and maintenance facilities.

Cape Cod and the Islands: Military, Cultural, & Other Characteristics

The Massachusetts Military Reservation (MMR) is approximately 23,000 acres in size and is located on Cape Cod within the towns of Sandwich, Mashpee, Falmouth and Bourne on the Upper Cape. This facility is home to units of the Massachusetts Army National Guard, Air Force Reserve and Coast Guard. In addition to its air field and aircraft support facilities, artillery and other weapons training has taken place there for decades. As a result of the various military activities over the years, there are several ground contamination sites located on and around MMR and remediation efforts are underway on many. Nomans Island, off the southwest shore of

Martha's Vineyard, was used by the military as a bombing practice site for decades. It is not currently open for public access due to the presence of unexploded ordinance. However, it has been subject to some clean-up efforts and is currently under the management of the U.S. Fish and Wildlife Service.

The region is also home to the Wampanoag Tribes of Mashpee and Aquinnah (Gay Head).

SOUTH COASTAL REGION (THE WATERS OF BUZZARDS BAY AND MOUNT HOPE BAY AND 16 COASTAL COMMUNITIES ADJACENT TO THOSE WATERS)

South Coastal Region: Summary

The South Coastal region is centered around two coastal embayments, Buzzards Bay and Mount Hope Bay. Mount Hope Bay is a sub-part of the much larger Narragansett Bay system primarily located within Rhode Island waters. The region's ocean resources have both a wide variety of uses and a high intensity of use. The region includes two of the Commonwealth's largest industrial ports, Fall River and New Bedford. These ports are home to the most valuable fishing port in the United States, extensive power generation facilities, and associated infrastructure, and other significant port uses. Buzzards Bay is a major shipping lane for petroleum and other cargoes that are brought to the Northeast. The region also contains extremely valuable shellfish and finfish resources, nationally significant endangered species, world-renowned recreational boating, and extensive relatively warm-water beaches. These resources help make the region a recreational playground and seasonal vacation area.

South Coastal Region: Natural Characteristics

The natural resources of the Mount Hope Bay portion of the region include extensive shellfish resources and a dynamic estuary at the mouth of one of the larger rivers wholly within Massachusetts, the Taunton River. This river system sustains one of the largest anadromous fish runs in the Commonwealth that has been used to supplement and help rebuild other fish runs in the state. Recreational fishing is still a favorite activity, although it has declined over the past decade or so from what many believe to be industrial impacts to fish stocks. Buzzards Bay's natural ocean resources include extensive endangered and rare species, including piping plovers, leatherback turtles, and more than one half of the North American population of the endangered roseate tern. Thousands of acres of salt marsh, tidal flats and eel grass beds help form the base of the bay's natural food chain. The bay also has ubiquitous and highly valuable recreational finfish resources including scup, tautog, blue fish, and striped bass. Buzzards Bay is home to some of the richest shellfish resources in the Commonwealth. The resources of both bays are threatened by pollution, primarily nutrients and bacteria from residential development and also from catastrophic events, such as the recent oil spill in Buzzards Bay.

South Coastal Region: Industrial Characteristics

The industrial ports of Fall River and New Bedford are significant economic engines for the region. Both ports receive cargo ships and, increasingly, cruise vessels. Fall River is the second deepest port in the Commonwealth, and is home to significant power generating infrastructure that serves users far beyond the immediate region. The port also has ferry and other boat-building operations, and is currently being considered for the location of major liquefied natural gas (LNG) receiving and handling infrastructure. Buzzards Bay acts as the southern funnel to the Cape Cod Canal, through which pass vast quantities of petroleum and cargo to Boston and other ports farther north. It is estimated that approximately two billion gallons of petroleum products pass through Buzzards Bay each year

New Bedford's fishing port for three years running has been the most valuable in North America with an extensive fleet that primarily fishes far off shore. The port also is home to a large and vibrant fish processing center that not only processes the local catch, but also large quantities of fish from other areas brought in by freighter and plane. There are significant large boat repair operations within the harbor. Ferry operations serving Martha's Vineyard have historically used the harbor and may be expanding in the near future. .

South Coastal Region: Commercial Characteristics

Small commercial fishing occurs seasonally throughout the region, but to a much greater extent in Buzzards Bay. Targets of these activities include lobster, scup and tautog, fished mostly by small boats either working out of local harbors or being brought in by trailer and launched for the day. Party boat activities for sport fish, such as blues, scup, and stripped bass, occur out of New Bedford Harbor. Smaller commercial sport fishing boats are available in many of the other numerous harbors throughout the bay. Although Mount Hope Bay's shellfish resources are not suitable for direct harvesting, there is a significant commercial shellfishery that harvests these resources and then transplants them to other parts of the state to augment the natural populations in those areas. There are extensive commercial shellfish activities in Buzzards Bay. In the late 1980s, it was estimated that Buzzards Bay was responsible for approximately one quarter of the states commercial shellfish harvest.

South Coastal Region: Recreational Characteristics

Both bays are home to significant recreational boating activities that continue to expand. Buzzards Bay in particular is world-renowned for its ideal sailing conditions. In the early 1990s, it was estimated that there were approximately 13,000 recreational boats moored or docked in Buzzards Bay, a relatively high percentage of which were sailboats. This expanding boat activity, while allowing more people to enjoy the region's natural resources, does present management challenges with competing uses, both recreational and commercial. Recreational shellfishing and fin fishing are favorite pastimes of many residents and visitors throughout the favorable seasons. The region's beaches are widespread and heavily used throughout the summer season. Along with the region's many town beaches, there are three state-owned facilities, each with significant beach resources, Horseneck Beach State Park, Demarest Lloyd State Park, and Nasketucket Bay Reservation.

South Coastal Region: Military, Cultural, & Other Characteristics

The United States Coast Guard (USCG) has a station in New Bedford Harbor. Recently the two large cutters stationed at this location for many years have been redeployed to other areas; however, other smaller boats may take their place.

Conclusion

As part of its efforts to prepare these characterizations of the uses of the state's oceans, the UCWG collected anecdotal information from Task Force members and the public regarding perceived ocean and coastal use trends. Many of these observations reflected concerns over increased usage and competition for ocean and coastal resources. To ascertain and quantify ocean and coastal trends, historical use characterizations provide a record of changes in uses, the decline or disappearance in historical uses, and the increase or emergence of new uses.

Although the OMTF work on use characterization was begun to help members understand the extent and nature of human activities in coastal waters, comprehensive use characterizations are important tools for ocean and coastal managers. An effective use characterization effort may be used in conjunction with natural resource data to illustrate the relationship between human activities and the marine environment, and over time to identify use trends. Complex use characterizations showing historical trends, overlays with natural resource characteristics, and cross-sections of the water column and the air above it are best displayed through a GIS-based dynamic system, similar to that used for MORIS.

SUMMARY OF ALTERATIONS BY HUMAN ACTIVITY AND CUMULATIVE IMPACTS

The objective of this portion of the Technical Report to the Ocean Management Task Force is to summarize and describe the major human-induced and natural impacts to estuarine and marine habitat and life. A thorough environmental assessment of cause and effects associated with the abundance of discrete human-induced impacts and natural processes or a comprehensive review of cumulative impacts is a complex issue and is beyond the scope of this report. Rather than a "cumulative impacts assessment", this report briefly explains cumulative impacts, describes major anthropogenic impacts and natural influences, lists Massachusetts examples of these impacts, shows the geographic location of key impacts, and presents emerging issues.

EXPLANATION OF CUMULATIVE IMPACTS

Alteration of estuarine and marine habitat and life by human activity – combined with impacts from naturally occurring environmental variation – leads to cumulative impacts to all sectors of the marine environment. Vestal et al. (1995) describes cumulative impacts as the combined outcome of numerous actions and stresses, where a group of relatively minor and major impacts may add up to severe habitat degradation or loss. This view is also shared by the Environmental Protection Agency, which asserts that cumulative impacts accumulate over time, from one or more sources, and can result in the degradation of important natural resources (EPA 1999).

According to The Council on Environmental Quality/National Environmental Policy Act regulations (40 CFR §§ 1500 -1508), and for the purposes of this report, we define "direct effects", "indirect effects" and "cumulative impacts" as follows:

- **Direct effects** are caused by the action and occur at the same time and place. (40 CFR § 1508.8)
- **Indirect effects** are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems. (40 CFR § 1508.8)
- **Cumulative impact** is the impact on the environment, which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. (40 CFR § 1508.7)

Additive effects and synergism are important topics to discuss while describing cumulative impacts but are different from cumulative impacts. Additive effects are the combined consequence of independent, multiple impacts; synergistic interactions are a more complex magnification of threats to produce a greater impact than additive effects. That is, the combined toxicity of two contaminants is (can be) greater (synergism) than their combined, independent toxicities (additive effects). These terms are frequently used while discussing multiple environmental impacts.

Cumulative impacts include additive and synergistic impacts and encompass wide-ranging ecological implications of human perturbation and natural patterns of variability. For example, the alteration of habitat and biological communities through the degradation of water quality due to point and nonpoint sources of pollution, high rates of organic loading to seafloor habitats as a result of watershed changes and increased run-off, and changes to species assemblages due to commercial exploitation leads to substantial loss to habitat and associated communities both spatially and temporally on a broad scale.

Because cumulative impacts affect a wide range of estuarine and marine habitats and all species (either directly or indirectly), they should be considered when developing ocean resources management strategies. However, it is difficult to achieve a clear understanding of the cumulative effects of human activities; specifically, separating human induced impacts from natural variation is a challenging but not impossible task (i.e., the cause and effect of many anthropogenic impacts are understood). Long-term systematic monitoring and targeted research are required to understand variability in natural resources and anthropogenic influences to natural resources. The status of ocean resources and the understanding of human-induced impact on ocean resources will remain difficult to understand without a substantial investment in monitoring and research.

While it is on occasion difficult to distinguish between human induced changes and natural variation, it is a well-known fact that anthropogenic changes contributed to extensive environmental stress in the Massachusetts marine environment. Regional efforts are ongoing to coordinate monitoring efforts, and Massachusetts should play a key role in developing monitoring and research plans and include efforts to understand cumulative impacts (CICEET 1999; cited in Concept Paper: Aquatic Habitats Northeast Indicators Workshop, January 6-8, 2004; Krahforst personal communication).

HUMAN-INDUCED IMPACTS AND NATURAL PROCESSES OF OCEAN RESOURCES

Increasing human population, particularly the coastal population, is the root of the majority of human-induced impacts. The northeastern United States (from Maine to Maryland) currently accounts for about one third of the nation's coastal population, and 16% of the entire national population (Culliton et al.1990). In the year 2000, 34% of the total Massachusetts population lived along the coast, demonstrating the extent of development along Massachusetts coastline. Please refer to human population section of 'Trends in the Demographics of Human Population and the Massachusetts Marine Economy' for a breakdown of the coastal population by county and town.

The demands of a high-density coastal population place a significant burden on coastal and ocean resources. For example, humans require wastewater treatment facilities and the associated disturbances have ecological consequences that extend to nearshore and offshore systems. There are many human uses of Massachusetts waters, and often these uses are conflicting; these uses should also be considered when examining human induced impacts (refer to 'Characterization of the Ocean Uses').

Summary of the Types of Human-Induced Impacts and Natural Processes in Massachusetts

Human-induced impacts and natural processes do not equally affect all resources and regions. Human-induced threats/impacts are both direct and indirect in nature. As seen in Table 1, direct human impacts from activities like dredging, siting of power plants and commercial fishing each have immediate impacts to the marine environment. Indirect human impacts include nonpoint source pollution and watershed development. Many of these activities may occur in coastal waters and contribute pollutants to the coastal zone, but their impacts, (like runoff of pollutants such as pesticides, herbicides and nutrients) are diffused over wide areas. Both direct and indirect human impacts cause environmental effects that are cumulative in nature.

There are many human-induced impacts, or sources of potential adverse impact, throughout Massachusetts waters. Table 1 shows major impacts, divided by type of anthropogenic impact (direct or indirect). Naturally occurring threats also influence ocean resources. Table 2 identifies global threats, divided by type of impact (natural disturbance and global climate change). Tables 1 and 2 list the geographic distribution of each type of impact. For the purposes of this section the following descriptions are applied:

- *Geographic distribution in Massachusetts* is a general representation of how these impacts are distributed along the state's coast and offshore waters. While the environmental effects of a particular threat or adverse impact may not necessarily be "widespread", "moderate" or "minimal", the following table illustrates the expanse of the impacts of the activity. For example, power plants are not present in all coastal areas, but power plants have wide-ranging impacts to many ecological functions. While a detailed illustration of the temporal and spatial scale or proportion of these impacts is not described, it is important to remember that several small-scale projects and broad environmental alterations result in a large cumulative impact. Additionally, sources of identified impacts may be more prevalent in certain areas as different parts of the coastline are only suitable for certain projects (e.g., shellfish aquaculture in Cape Cod Bay).

- *Coastal & offshore construction/shoreline armoring* (under direct impacts) includes any building and/or erosion control barriers in the shoreline, nearshore or offshore areas (e.g., dock and pier construction, proposed windmill energy projects, and fish pens for aquaculture), while *watershed development* (under indirect human impacts) is meant to include all landscape alteration and construction in coastal watershed areas located upland. These two categories are not always discrete.

Table 1. List of types of human-induced impacts that affect ocean resources in Massachusetts (adapted from Wilbur and Pentony (1999); Concept Paper: Aquatic Habitats Northeast Indicators Workshop, January 6-8, 2004).

TYPE OF IMPACT	GEOGRAPHIC DISTRIBUTION IN MASSACHUSETTS			
	Widespread	**Moderate**	**Minimal**	**Unknown**
DIRECT HUMAN				
Coastal & offshore construction/ shoreline armoring	■			
Filling			■	
Dredging	■			
Dredged material disposal		■		
Sand mining			■	
Damming		■		
Pipelines/cables construction			■	
Sewage treatment plants	■			
Power plants	■			
Industrial discharge/outfalls	■			
Commercial fishing/harvest	■			
Shellfish aquaculture		■		
Recreational boating	■			
Marine/ferry transportation		■		
INDIRECT HUMAN				
Watershed development	■			
Nonpoint source pollution	■			
Air pollution	■			
Boat fuel and wastes		■		
Ballast-water discharge		■		
Oil/toxic spills			■	
Algae blooms		■		
Disease		■		■
Invasive species	■			■

Natural processes include natural disturbances and global climate change, but these global phenomena are often influenced by human activities (e.g., contribution of greenhouse gases to the atmosphere increase rates of global climate change). The geographic effects of these processes are largely unknown, as are the long-term environmental consequences, although they are assumed to be pervasive and far-reaching. Substantial volumes of science are beginning to demonstrate the ecological consequences of these large-scale processes (through space and time); 'Oceanography, Weather Patterns, and Climate Change' provides a summary of climate change and weather patterns.

Table 2: List of regional/global processes affecting Massachusetts ocean resources. Note: impacts associated with natural disturbance and global climate change are often exacerbated by human activities.

TYPE OF IMPACT	GEOGRAPHIC DISTRIBUTION IN MASSACHUSETTS			
	Widespread	**Moderate**	**Minimal**	**Unknown**
NATURAL DISTURBANCE				
Storms				
Climatic processes				
Biotic processes				
GLOBAL CLIMATE CHANGE				
Accelerated sea-level rise				
Ocean warming				
Atmospheric ozone depletion				

DISTRIBUTION OF CUMULATIVE IMPACTS

An example of the result of cumulative impacts is seen through changes in water quality over time. Direct human impacts along the Massachusetts coast, like construction of industrial discharge/outfalls (Figure 1), dredging and dredged material disposal (Figure 2 and Figure 3), when combined with indirect human impacts like watershed alteration and nonpoint source pollution (chemical agricultural runoff, including pesticides and herbicides, and stormwater runoff), and oil/toxic spills, have significant effects on the environmental quality of Massachusetts over time. This is a brief example of the extent and type of major impacts to the ocean resources in Massachusetts. The impacts identified in Table 1 and 2 and shown in the figures represent individual activities that affect ocean resources; the tables and figures do not describe ecological consequences of these impacts and activities.

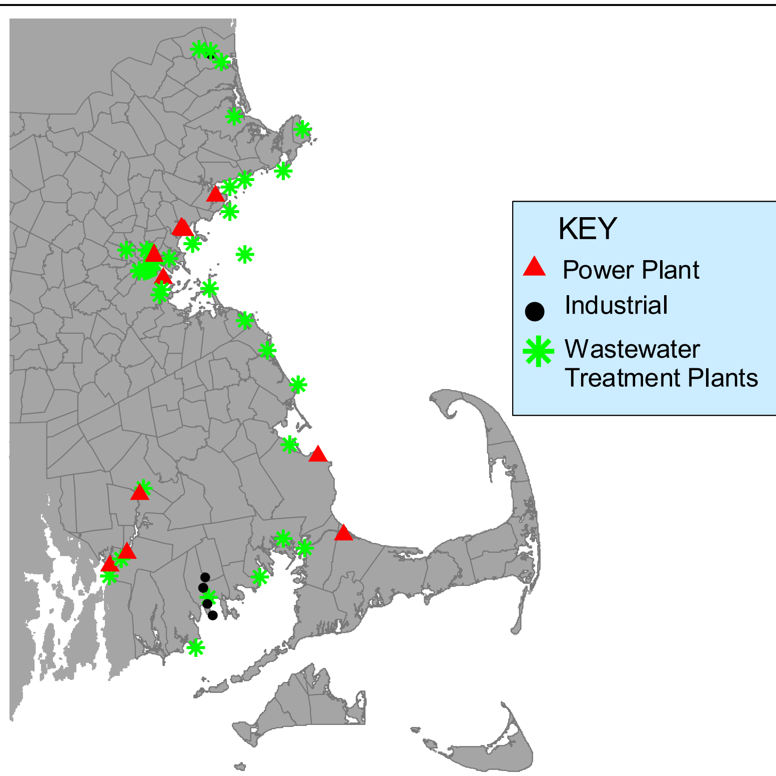

Figure 1. Major discharges with National Pollutant Elimination System (NPDES), including power plants, industrial effluent and wastewater treatment facilities.

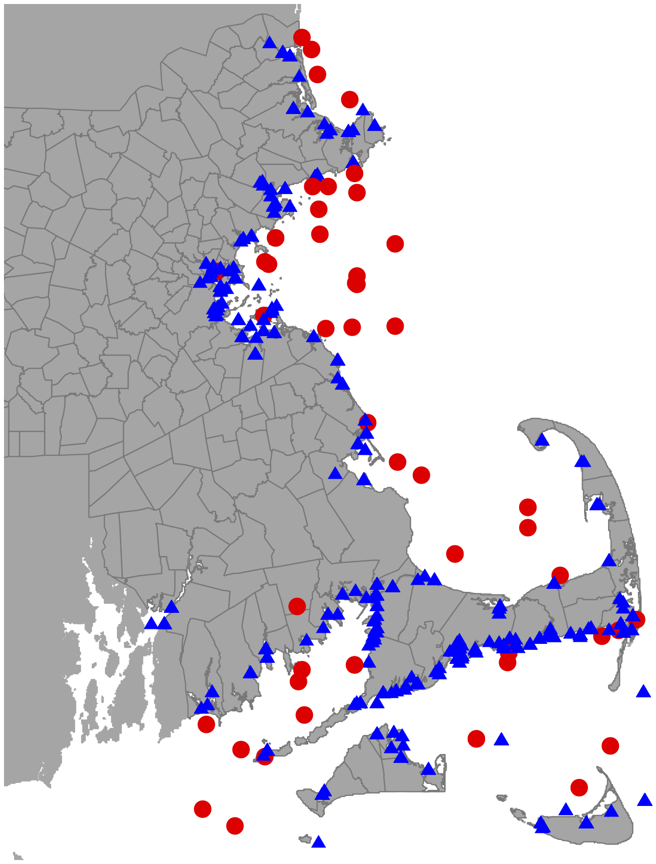

Figure 2. Historic dredging locations (▲) and dredged material disposal sites (●); dredging and disposal locations were generated based on issued permits - not the actual dredging or disposal that occurred. The figure provides an estimate of the statewide distribution of dredging and disposal.

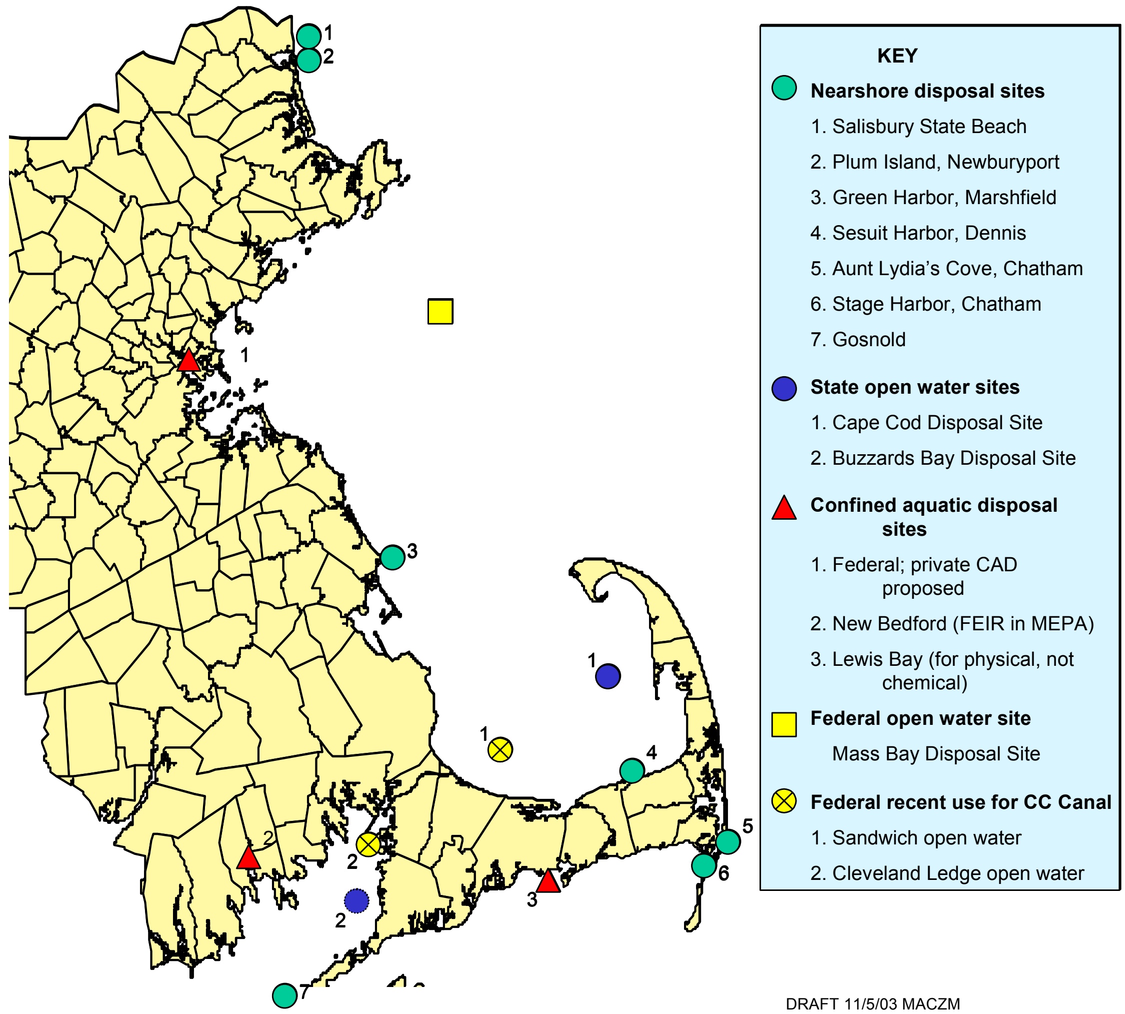

Figure 3. State and federal dredged material disposal sites; locations of existing or recently used sites.

When considering the geographic distribution of environmental impacts, the recreational boating industry provides a good example. There are 270 recreational marinas along the Massachusetts coast, with most having 50 slips or more each in the year 2000 (Lacey, personal communication). The distribution of harbors and ports (Figure 4) provides a generic estimate of areas heavily used by recreational boaters and also shows the location of industrial vessel activity. Recreational boating activities from these marinas (including additional boats using marinas for daily access) potentially stress the marine and coastal environment and present a number of dangers. A gathering of vessels leads to a higher potential and concentration of toxic spills, including fuel, paint, chemical solutions to remove fouling organisms and other cleaning materials. Recreational vessels also contribute to direct habitat degradation (e.g., seagrass scarring from propellers, anchors and moorings) and overall noise pollution from motor activity. In addition, marina infrastructure such as floating docks, buoys and pilings offers opportunities for invasive species attachment and alter environmental conditions.

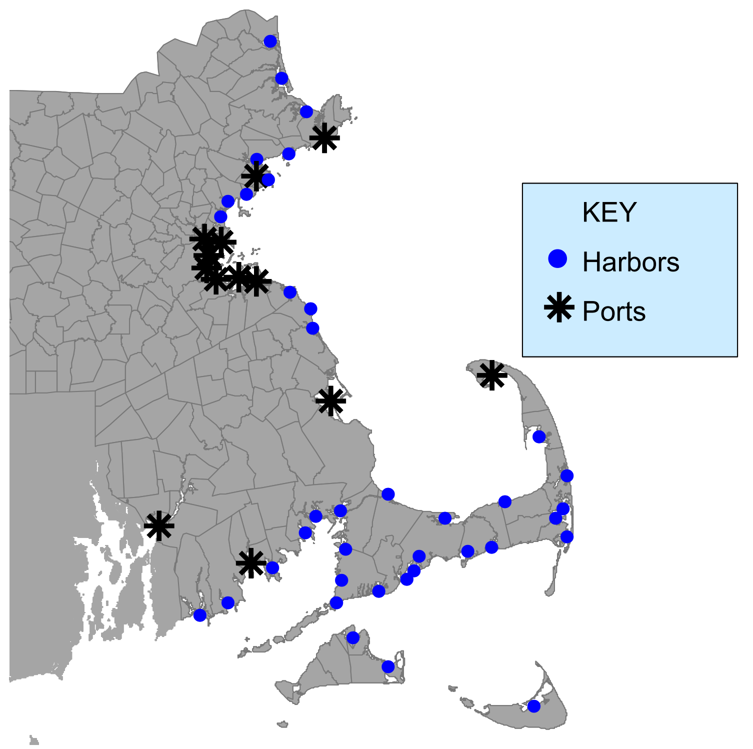

Figure 4. General estimate of the distribution of harbors and ports in Massachusetts.

While recreational marinas are located along the entire coast, most of the individual towns that have five or more recreational marinas are in southern Massachusetts, including Buzzards Bay, Edgartown, Falmouth, Hyannis, New Bedford, Fairhaven and Vineyard Haven. In addition to the recreational boating, there is already wastewater treatment, harbor development, and dredging and disposal in these areas. Newburyport (10 marinas), Gloucester (12 marinas), and Falmouth (13 marinas) also have substantial numbers of marinas for individual municipalities.

CUMULATIVE IMPACT EXAMPLE: BOSTON HARBOR

The density of harbor and port construction reflects a highly populated coastal area, namely in the Boston Harbor area (Figure 4). Human induced impacts are more heavily concentrated in Boston Harbor than in other areas along the Massachusetts coast. Johnson and Rodrigues (2004) developed three maps to illustrate impacts in the area. The extent and type of environmental impacts in Boston Harbor serve as an example of the abundance and diversity of human influences that affect ocean resources.

When considering human impacts, it is important to remain conscious of the marine and coastal habitats that continue to be threatened (Figure 5). Despite the progress of the Boston Harbor cleanup, there are still many environmental issues to address. There are several hazardous waste sites (including sites of Superfund National Priority) and an influx of point source pollution concentrated around the harbor (Figure 6). In addition, direct impacts from activities such as dredging and dredged material disposal and coastal and underwater construction continue to affect the area (Figure 7).

Figure 5. Marine and coastal resources in Boston Harbor; figure shows key marine and coastal resources, including known rocky bottom, eelgrass beds, ACECs, etc. (Johnson and Rodrigues 2004).

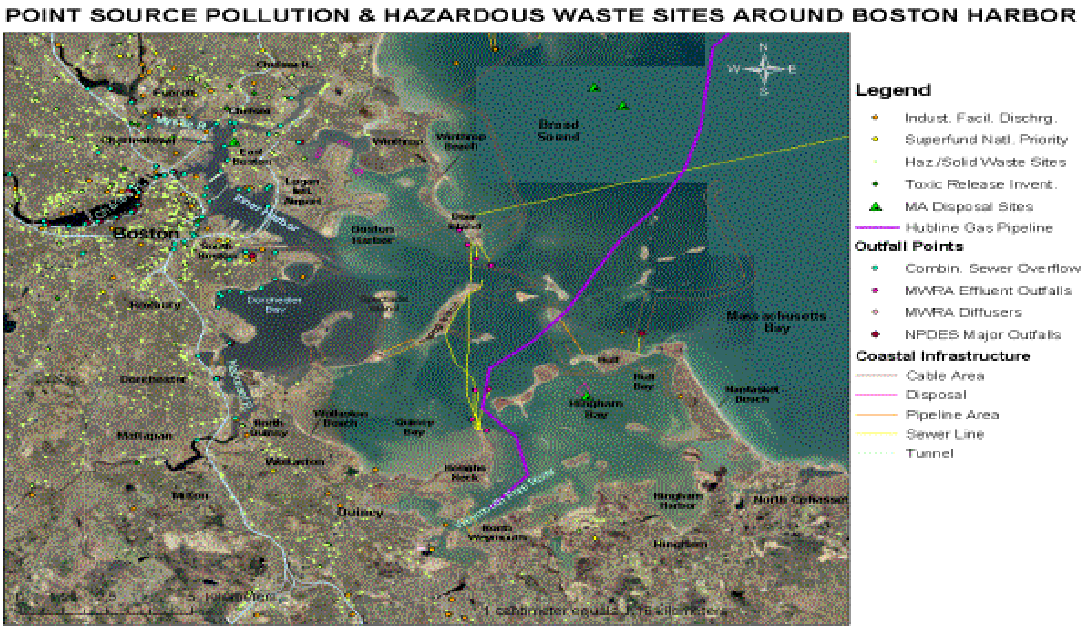

Figure 6. Point source pollution and hazardous waste sites around Boston Harbor; figure illustrates point source pollution, hazardous waste sites, Hubline gas pipeline, cables, sewer lines, etc. (Johnson and Rodrigues 2004).

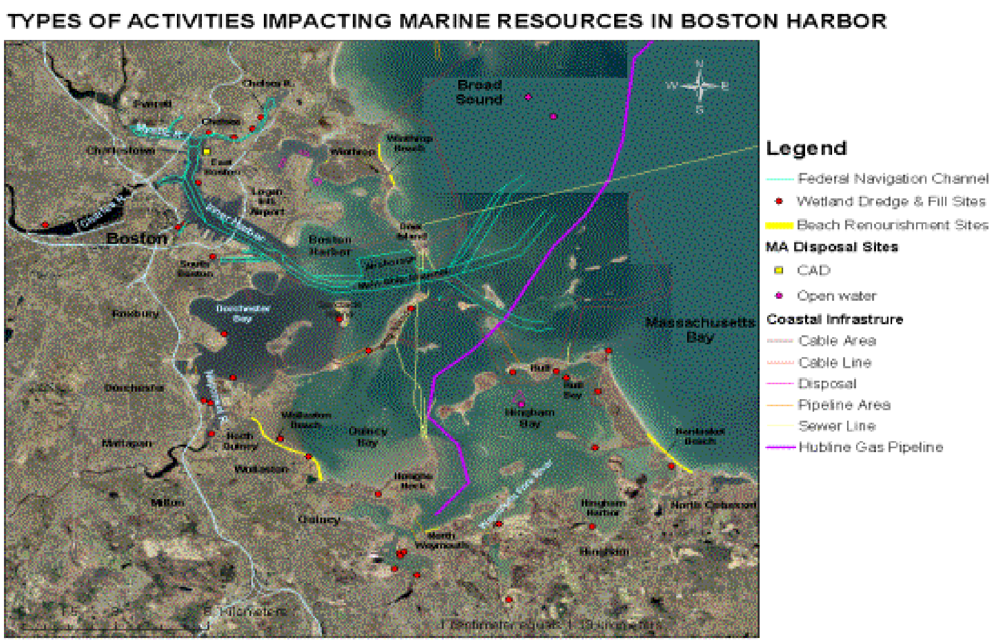

Figure 7. Types of activities impacting resources in Boston Harbor; figure shows navigation channels, wetland dredge/fill sites, beach renourishment and confined aquatic disposal locations (Johnson and Rodrigues 2004).

EMERGING ISSUES

The identified threats and examples of cumulative impacts in Boston Harbor are an overview of a complex issue. These identified impacts along with additional unidentified threats potentially influence ocean resources in Massachusetts. Massachusetts waters have always supported many human uses. In addition to the above discussed existing anthropogenic impacts, the following are a few emerging issues which we anticipate to contribute to cumulative impacts in the future:

- Energy facility development (e.g., windmills) and similar proposals to use marine environment as a means of creating renewable energy;
- Desalination plants;
- Sound pollution (including Navy, National Defense and recreational vessel sonar, dynamite used in pipeline, CAD and cable construction, boat engines, dredging/sand mining operations and exploration for oil and gas resources);
- Increasing shellfish aquaculture and fish farm development; and
- Continued construction of docks, piers, floating hotels

SUMMARY

Cumulative impacts in estuarine and marine habitats are important to consider both now and into the future to ensure environmental quality and improve the status and condition of ocean resources in Massachusetts. An understanding of the type, diversity, distribution and ecological implications of these threats can assist in the development of ocean resources management practices. A thorough ocean resources research and monitoring plan designed to evaluate natural variability and human-induced impacts in the ocean resources of Massachusetts is fundamental to understanding cumulative impacts.

Although major impacts to estuarine and marine habitat and life caused by human activities and natural processes are identified in this report, it is important to recognize that many other anthropogenic caused impacts threaten the quality of the ocean environment in Massachusetts. Cumulative impacts should be recognized while developing ocean resource management plans for Massachusetts; activities which may initially appear to be small-scale, can still prove to have substantial effects for the long-term ecological sustainability of the marine and coastal environment.

A few natural processes or global phenomena that – as an individual state – Massachusetts has little control over were identified; however, Massachusetts has a degree of control over many of the anthropogenic impacts, which can lend themselves to management by the state – which is the subject of many of the Task Force's recommendations. The distribution of key impacts show that few areas along the Massachusetts coast remain undisturbed by human impacts, with Boston Harbor being one of the most heavily used areas. This section also noted emerging issues that are expected to become of greater importance as future management strategies are negotiated. Cumulative impacts will remain a notable challenge without a comprehensive research and monitoring plan and guidelines to evaluate human-induced alteration to ocean resources in Massachusetts.

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OCEANOGRAPHY, WEATHER PATTERNS AND CLIMATE CHANGE

OCEANOGRAPHY

The oceanography of Massachusetts is influenced by physical, chemical and biological processes that act on regional and local scales. The North Atlantic Oscillation, for example, is a large global climatic pattern that influences the oceanography of the North Atlantic Ocean (including Massachusetts), and individual rivers entering Massachusetts coastal waters affect oceanographic conditions, such as current, salinity and temperature. These small and large features interact to influence the oceanography and ecological function of Massachusetts.

Massachusetts is located between two large marine systems, the Gulf of Maine (part of the Acadian province) and southern New England (part of the Virginian province). Forty-one percent of the Massachusetts coastline is bordered by the Gulf of Maine. The Gulf of Maine is a semi-enclosed sea, with Georges Bank and Browns Bank forming a barrier to the south and east, and the New Hampshire, Maine, New Brunswick, and Nova Scotia coastlines containing the Gulf.

Situated in the western Gulf of Maine, the Massachusetts and Cape Cod Bays are partially isolated from the rest of the Gulf by Stellwagen Bank. On either side of the Bank are two channels: one between Cape Ann (Gloucester) and Stellwagen Bank; and, the other, between Race Point (Provincetown) and the Bank. Stellwagen Basin is the deepest portion of Massachusetts Bay, with a depth of 80 m; the depths of the channels are 60 m and 50 m, respectively.

There is a persistent counterclockwise current in Massachusetts Bay that also exists in the Gulf of Maine; however, seasonal variation in direction and intensity of the major currents and many smaller currents exist. The major current enters south of Cape Ann, flows south through most of the Bay, and exits north of Race Point. The currents in Cape Cod Bay are fairly weak except during a run-off period when the counterclockwise circulation existing in Massachusetts Bay flows to Cape Cod Bay.

Southern Massachusetts is found in southern New England, which is considered the northern edge of the Mid-Atlantic Bight. Nantucket Shoals, a submerged sand and gravel shallow ridge, extends southeastward from Nantucket Island. Buzzards Bay is a relatively shallow estuary with depths to slightly over 20m. There are two major currents in the Bay; the first running parallel to Naushon Island and terminating near Woods Hole (average current speed=0.6 to 0.8 knots); and the second runs along the northwest shore of the Bay (average current=0.6 knots).

The Gulf Stream brings warm water from the south, from the coast of Florida, moving east off the North Carolina coast and then northeast across the Atlantic Ocean. At the Grand Banks, the Gulf Stream changes from a single front to two branching fronts: one branch is called the North Atlantic Current and curves north along the continental slope, eventually turning east; the second branch is called the Azores Current and flows southeastward towards the Mid-Atlantic Ridge.

Coastal Landforms

The Massachusetts coast is lined with a diversity of landforms, including salt marshes, barrier beaches, estuaries, salt ponds/coastal embayments, open coastal waters, and rocky shores. It is this diversity that provides varying tidal and current characteristics; and this diversity is an illustration of the geology throughout Massachusetts, with rocky outcrops more prevalent north of Cape Cod and a higher proportion of sandy environment in southern Massachusetts (please refer to the Estuarine and Marine Habitat section for further information on coastal habitats and land forms).

Major Currents and Tides

Tide is the vertical rise and fall of water accompanied by the horizontal movement of the water, known as a tidal current. The moon and sun generate tidal forces. However, weather, seismic events, or other natural forces also influence tides and river flows; floods or other non-tidal currents also affect tidal currents. Current is affected by differences in bathymetry or the depth of the ocean. Currents and tides are also affected by wind and atmospheric pressure (NIMA 1995). The movement of water by tides, currents and waves influence environmental processes from nearshore to offshore waters, such as erosion and deposition of sediments.

Across the Massachusetts coast, the mean tide range (measurement of the rise and fall of the water between high and low tides) ranges from one to thirteen feet. In extreme weather events, for instance the Blizzard of 1978, the tide was five feet above normal high water, which resulted in the highest tide recorded at Boston Harbor's NOAA Station. The lowest tide recorded was approximately four feet below normal low water in March 1940.

There are many local currents along the Massachusetts coast. For example, White (2004) noted one of the strongest currents on the Massachusetts coast is at the Woods Hole Cut that connects Buzzards Bay with Vineyard Sound and averages a maximum velocity of 4.5 knots. Average current velocities through the man-made Cape Cod Canal approach 4.5 knots, the result of significant tidal height differences between Cape Cod Bay and Buzzards Bay. The location or characteristics of small, localized currents are generally not identified or described.

Riverine Inputs

Riverine systems are comprised of streams and rivers, connecting upland streams and wetlands with the ocean. Rivers carry freshwater, nutrients, and pollutants throughout the watershed. Riverine systems, estuaries, and other systems that include freshwater marshes, swamps, bogs, lakes, etc. form the Commonwealth's watersheds. Eventually, all Massachusetts watersheds drain into a coastal water body; these include the Massachusetts/Cape Cod Bays complex, the Vineyard Sound/Nantucket Sound/Atlantic Ocean area, Buzzards Bay, Mount Hope Bay, Long Island Sounds or New York Harbor (MCZM/MME 1992).

The United States Geological Survey (USGS) collects data on the variations of stream flow across Massachusetts. Flanagan (1999) states the largest rivers carry the greatest amount of stream flow; the Merrimack River is the largest river in Massachusetts. Stream flow is typically highest during spring runoff and snowmelt; however, fall rains may also be substantial.

There are no extraordinarily large rivers entering Massachusetts Bay, south of Cape Ann; the largest entering southern waters of the Bay is the Charles River at an average annual discharge rate of 10 $m^3 s^{-1}$ and the Merrimack River has a substantial average annual discharge, 320 $m^3 s^{-1}$, and enters northern Massachusetts Bay. There are several freshwater riverine influences north of the Bays into the Gulf of Maine; the Penobscot River has an average annual discharge of 475 $m^3 s^{-1}$ and the Androscoggin and Kennebec Rivers have an average annual discharge rate of 320 $m^3 s^{-1}$. These riverine discharges influence water conditions in Massachusetts.

Aside from the Charles River, the MWRA discharges into the Massachusetts Bays via Boston Harbor and contribute a substantial volume of freshwater to the Bay. Together, the Charles River and MWRA discharges account for only a few percent of the discharge of the Gulf of Maine Rivers. Geyer et al. (1992) states that the percentage of other rivers discharged into the Bays appears highly variable and has not been well quantified. These rivers may include the Ipswich, Neponset, and Acushnet Rivers, among others.

WEATHER CONDITIONS

Continental air masses from the south and west and warm air from the Gulf of Mexico influence the Massachusetts climate. Weather conditions in the North Atlantic region are controlled by the Bermuda high pressure system. This condition results in frequent showers, thunderstorms, high humidity, and low wind speeds in the spring and summer and, in the winter, can result in frequent and abrupt day-to-day variations in pressure, wind, and weather when combined with faster moving and more intense winter pressure systems (Field 1980).

Generally, winds vary over seasons in Massachusetts. Summer winds typically are weak from the southwest or southeast and bring warm, moist air that can contribute to fog formation; winds from the north or northwest are typical for autumn and winter (GoMOOS 2003). Spring and summer southwesterlies may drive hurricanes northward from cross Atlantic or Caribbean tracks and have the potential to harm the Commonwealth's south-facing shores (e.g. Buzzards Bay and the south coast of Cape Cod). The storms of autumn or winter, "nor'easters," also have particularly strong winds and may drive winter storms into northeastern-facing shores (e.g. Massachusetts Bay and the outer Cape) (MCZM/MME 1992). Storm surge is another hazard characterized by elevated sea level along a coast caused by storms. Coastline shape, nearshore depth and wind strength and direction all determine the severity of storm surges (GoMOOS 2003).

Recently, Wind Energy Resource Maps were developed for New England, in a collaborative effort by the Connecticut Clean Energy Trust, Northeast Utilities and the Massachusetts Technology Collaborative. This report and accompanying maps may be found online at http://www.mtpc.org. Wind conditions were projected using the MesoMap system: A Mesoscale Atmospheric Simulation System (MASS) that is a numerical weather model using online, global, geophysical, and meteorological databases. This system creates a wind resource map by simulating weather conditions over 366 days selected from a 15-year period.

According to the report and maps, a concentration of the wind resources of Massachusetts are in the hills of western Massachusetts, coastal areas, and offshore. Offshore winds are predicted to be very strong with mean speeds of at least 8.5m/s at distances greater than 10-20 km from the shore at 65 m above the effective ground level (2/3 the height of tree tops or 10 m). On land the mean speed at the same height typically range from 5.5 to 7 m/s. The main factor for this difference is "surface roughness"; forests exert friction on the atmosphere causing the speed near the surface to be reduced. However, taller hills and mountains in western Massachusetts have mean wind speeds at the highest points predicted to exceed 9m/s; these areas may have strong winds occurring aloft. Moderate ridges show predicted speeds of 6.5-8 m/s. Small peninsulas and exposed islands may also be locations for a productive wind resource, such as Cape Cod, Nantucket or Martha's Vineyard.

CLIMATE CHANGE

Over the next century, climate change is projected to profoundly impact coastal and marine ecosystems, not just in Massachusetts but also, around the globe. Such trends as sea level, increased coastal flooding, inundation of wetlands, and changes in ocean and atmospheric circulation are predicted to occur.

These effects have been observed in many recent reports, including those recently issued by the Conference of New England Governors – Eastern Canadian Premiers in their Climate Change Action Plan (August 2001):

> Scientific evidence of the destabilizing human influence on global climatic systems is continuing to build, creating a growing momentum for a response. For example, the Intergovernmental Panel for Climate Change (IPCC), an international body of atmospheric scientists, in its *Third Assessment Report*, states that "There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities." …. The IPCC predicts that if no action is taken, average rates of warming by 2100 will "be greater than any seen in the last 10,000 years." Such instability will increase the incidence and severity of extreme weather events such as storms, droughts, floods, and heat waves; cause sea levels to rise; shift and/or expand certain disease and pest vectors; and further stress already vulnerable species and ecosystems.
>
> In the *Canada Country Study, Atlantic Region Report*, for example, scientists predicted that sea level rise is the impact with the highest degree of certainty associated with it and will lead to predictable and dramatic impacts. Many of these impacts would be common to the Eastern Canadian provinces and to New England states. The warming would stress our common natural resources—especially in the areas of agriculture, fisheries and forestry. Another recent analysis of regional impacts of future climate change in the United States, concluded that key issues for New England (and we can assume for the Eastern Canadian provinces as well) were likely to include an increase in weather

> extremes; stresses on estuaries, bays, and wetlands; changes in precipitation rates impacting water supply and food production; multiple stresses on urban areas; and recreation shifts. …. Rising sea level and elevated storm surge levels—with associated problems of coastal erosion and saltwater inundation—would likely have severe impacts on our harbors, islands, and for the many communities located near the region's shoreline.

Additionally, as cited by the recent Pew Ocean Commission, among the effects of climate change on the oceans are: changes in precipitation, wind patterns, and the frequency and intensity of storms; warming temperatures will influence reproduction, growth, and metabolism of many species in stressful or beneficial ways, depending on the species; impacts (potentially beneficial as well as harmful) on aquaculture; species migration, which could change the mix of species in particular regions; sea-level rise could threaten the survival of marshes; changes in wind patterns could affect coastal and estuarine circulation patterns and upwelling and downwelling of water in marine systems; changes in the frequency and intensity of storms could increase flooding and threaten coastal aquaculture and fishing industry facilities; natural climate variability, such as El Niño events, results in changes in open-ocean productivity, shifts in the distribution of organisms, and modifications in food webs, foreshadowing what would happen if climate change accelerated; changes in temperature or salinity of North Atlantic water in the Arctic, which may slow or shut down the slow-moving thermohaline circulation that delivers cold, dense, oxygenated water to the deep sea; and climate-induced changes in ocean chemistry could diminish the abundance of microscopic open-ocean plants and animals. (Pew Commission, "America's Living Oceans: Charting a Course for Sea Change," May 2003, Chapter 7.)

Clearly, as a state with significant ocean and coastal resources, Massachusetts has had to and will need to continue to adapt to effects such as these. For example, an examination of the Massachusetts coast on the geologic timescale shows that the climate and sea level have been quite variable. The climate of the earth has been warmer, glaciers melted and sea levels were higher; up to 100 meters higher between the Nebraskan and Kansan glacial periods. The climate of the earth was also cooler and with the capture of the water in glaciers the sea levels lower, up to 100 meters lower at the height of the last glacier period called the Late Wisconsin Period about 17,000 years ago. Since that time, glaciers melted and sea level rose at a rate of about 40 inches per century (0.033 ft/yr). The rate of sea level rise is not constant; geologists estimate the peak rate was approximately 30 feet per century (0.300 ft/yr), occurring about 6,000 years ago when all low-lying coastal areas were flooded. In the last 6,000 years, sea level change was not as dramatic, with sea level no more than 10 to 12 feet higher or lower than it is today. The current amplitude of the sea level oscillation also appears dampened in the past 6,000 years, going from 20-foot oscillations to five-foot oscillations (Fairbridge 1960).

Climate change and sea level change are related, and anthropogenic impacts can be added to the many natural variables that affect climate and sea level. The Intergovernmental Panel on Climate Change (IPCC) noted that the average surface temperature of the earth has increased since 1861, and has increased over the last 100 years by about 0.6°C (1°F). The 1990s was the warmest decade since instrumental recording began in 1861, with 1998 being the warmest year. Global sea level has risen 10-20 cm (4-8 inches) over the past century; and there was an increase in the heat content of the upper 300 m (985 ft) of the ocean by about 0.04°C (0.07°F) since the 1950s (IPCC 2001).

This warming has been attributed to increases in greenhouse gases, particularly carbon dioxide, methane, water vapor, chlorofluorocarbons and nitrous oxide. The warming rate of the earth depends on the ability of the atmosphere to achieve equilibrium, the rate of increase in atmospheric CO_2 and other greenhouse gases and the ocean's capacity to absorb heat that would warm the earth's atmosphere.

Global warming raises sea level in two ways. First by thermal expansion, warming will decrease the density of ocean water thus increasing its volume (i.e., the same amount of water will take up more space when heated). The rate at which more space is taken depends on how much heat is absorbed by oceans. The second way sea levels rise from global warming is by the transfer of snow and ice from land to the sea. Glaciers contain large volumes of water trapped as ice and melt, resulting in water entering the ocean and raising sea level (if not displaced by increased snowfall on land or glacier formation). The melting of the glaciers may be a phenomenon in which a threshold exists. Once the threshold is exceeded, glaciers may melt at an exponential rate, regardless of climate change, thus increasing water run off to oceans and sea level rise (self-reinforcing process / cascading effect).

<u>Measuring Sea Level</u>

Tide gauges are instruments usually located on piers that continuously measure sea level height. The gauge's height is precisely leveled at a known benchmark height (marked in bedrock). Hicks et. al. (1983) examined data from 44 (of the 67) permanent tide gauge stations operated by the National Ocean Service which were operational prior to 1940 and had few breaks in their measurement series. Two of these stations are in Massachusetts – Boston and Woods Hole.

The Boston station is located behind the Coast Guard Offices on Atlantic Avenue on the old Northern Avenue Bridge (latitude 42° 21.3' N, longitude 71° 03.0W). The first full year of tidal information was 1922 and it has been providing data since that time.

The Woods Hole gauge is located at the Woods Hole Oceanographic Institution (latitude 41° 31.5' N longitude 70° 40.4W). The first full year of tidal information was 1933, and data from 1965 and 1967-1969 is not available.

Hicks et. al. (1983), among other analyses, examined the yearly mean sea level that is the arithmetic mean of a calendar year of hourly heights through 1980. Boston and Woods Hole both showed increasing trends in sea level height, with increase in Boston at 2.3 mm/year (0.008 ft/year) and increases in Woods Hole at 2.7 mm/year (0.009 ft./year).

Sea level data is available through 1993 from the National Ocean Service's web site (http://www.co-ops.nos.noaa.gov/seatrnds.html). Boston and Woods Hole continue to show increasing trends of 2.64 mm/yr (0.0084 ft./yr) and 2.48 mm/yr (0.0081 ft./yr), respectively. Data only using the series from 1950-1993, a common series for all stations, show increasing trends of 1.74 mm/yr (0.0057 ft./yr) for Boston and 2.05 mm/yr (0.0067 ft./yr) for Woods Hole.

All areas in the United States, except the northern west coast (northern California, Oregon and Washington), show increasing sea level trends. Sea level is increasing from 1.0 - 2.6 mm/year (0.003 ft.- 0.009 ft.). The northern west coast has a negative trend of -0.4 mm/yr (-0.001 ft./yr). The United States overall has an increasing trend of 1.3 mm/yr (0.004 ft./yr.).

Another method to measure sea level is with a satellite altimeter, which measures the sea level from a precise orbit around earth. These measurements of global sea level change are very exact over shorter periods of time. Since August of 1992, the TOPEX/POSEIDON satellite mission measured sea level on a global basis every 10 days with unprecedented accuracy and precision; these data can be used to further evaluate changes in sea level.

SUMMARY

Oceanographic conditions in Massachusetts are fairly unique. Massachusetts is part of the Gulf of Maine and southern New England. The oceanography of our region is not fully described, but ongoing monitoring efforts (e.g., Gulf of Maine Ocean Observing System; GoMOOS) are improving our understanding of the variability of oceanographic conditions (e.g., water movements). Temporal and spatial variance in oceanographic conditions are important to identify because this variability affects natural resources and weather. Climate change, for example, can have substantial impacts on coastal and ocean resources. Climate change and sea level rise will alter hydro-cycles, and the results could be more intense storms and more extreme floods and droughts. Sea level rise will also cause beach erosion and beach narrowing, dune and bank erosion, wetland loss, alteration of species assemblages, infrastructure usability loss and the possibility of complete loss, low lying area flooding, island re-sizing, and ground water implications. A comprehensive ocean resources monitoring and research plan should encompass a range of oceanographic measurements and indicators of climate change and sea level rise.

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LIVING MARINE RESOURCES

The Living Marine Resources Technical Report is an overview of (1) fishery resources, including major fishery dependent monitoring programs (commercial and recreational fish landings), fishery independent monitoring and population trends of fishery species (finfish and lobster), and commercial and recreational shellfish landings, (2) population status of marine mammals and sea turtles, (3) seabird, shorebird, waterfowl and colonial waterbird populations, (4) large scale benthic community monitoring programs, and (5) status of marine bioinvaders.

1. FISHERY RESOURCES

In this section, the major data collection and monitoring programs that characterize the fishery resources, including finfish, lobster, and shellfish of Massachusetts marine and estuarine waters are described. By definition, the data programs that collect commercial and recreational fishery landings information characterize only species that are of either commercial or recreational significance. The fishery independent monitoring programs that are in place and implemented by the Massachusetts Division of Marine Fisheries (*MarineFisheries*) characterize the populations of organisms that are susceptible to the limited array of sampling devices (e.g., otter trawls and lobster traps). There are many Living Marine Resources, including a wide variety of organisms (e.g., benthic invertebrates, phyto- and zooplankton, small cryptic fishes, pelagic fishes) and environments, such as shallow water embayments and estuaries, that are not well characterized by the present programs. Characterization of populations with limited data is not included. Examples of the population status for exploited species through time are provided only for select species and geographic areas. Specifically, this summary relies on data collected only in state waters by *MarineFisheries* (i.e., does not include a summary of federal fishery programs, such as NOAA's National Marine Fisheries Service - NOAA Fisheries).

Characterization of a particular fish or invertebrate species deemed significant or important generally takes place in the context of direct or indirect economic value, although some species such as herring are also recognized for their value as forage (food) for other species. Several factors contribute to the characterizations of economically valuable species:

- *Historical use of the species* – Species such as striped bass and lobster have been harvested off the Massachusetts coast for at least 400 years, and cod even longer.
- *Value of landings* – American lobster, for example, is Massachusetts most valuable single species fishery (landings are typically worth $50-60 million dollars annually).
- *Indirect value to local economies* – Money spent on lodging, meals, boat charters, and the like in the pursuit of species such as striped bass, bluefish, or tuna that support a significant portion of the local economy of many coastal towns.
- *Compliance with Federal or Regional Regulatory Processes* – As well as the species mentioned above, numerous other species such as scup, black sea bass, winter flounder, squid, conchs, and summer flounder, are regulated under multi-state management plans that require the collection of landings data.

Further data on landings and population status are available through NOAA Fisheries (e.g., Status of Fishery Resources; Clark 1998). The NOAA documents present changes in traditionally exploited species (e.g., groundfish and flounders) and species that have recently gained economic value (e.g., skates and dogfish).

A. Commercial Fish Landings

MarineFisheries and NOAA's Fisheries manage a long-term database on the landings of commercially valuable species. These data sets provide the foundation to monitor and examine trends in species landed throughout the Commonwealth.

The Atlantic Coastal Cooperative Statistics Program (ACCSP; see www.accsp.org for more information about the program) has existed for several years. The goal of ACCSP is to collect and manage compliant or trip-based, commercial landings, and catch and effort data, in Massachusetts, with all partners (all Atlantic States and Federal Agencies) Massachusetts is unique in that two organizations, *MarineFisheries* (DMF) and NOAA Fisheries (NMFS) both have established commercial fisheries landings and catch and effort data collection mechanisms in place.

CURRENT STATUS OF LANDINGS DATA

1. ***MarineFisheries* (MA Division of Marine Fisheries)**: *MarineFisheries* has been collecting commercial landings and catch and effort data in one form or another for over thirty years. The emphasis of this data collection effort has been directed at the lobster fishery, as it is the most economically important fishery conducted within the state's territorial waters. Other fisheries include striped bass, fluke, fish weir, gillnet, fish-pot (sea bass, scup, and conch) and shellfish. This information is collected via annual catch reports, submitted at license renewal time, which detail catch and effort data by month, not by trip. In addition, DMF *MarineFisheries* collects dealer landings data on a weekly basis from dealers who have authorization to purchase quota monitored species. These weekly purchases are corroborated by year-end transaction sheets, or federal dealer weigh-out slips, which detail each transaction with fishermen. Finally, DMF *MarineFisheries* issues permits to all commercial fishermen and seafood dealers in Massachusetts. This is important as *MarineFisheries* can identify all fishermen and dealers in the state, regardless of whether they have a federal permit or not.

   While *MarineFisheries* collects these important landings data, there are several known problems in the current monitoring programs. For example, data is not trip-based, data reporting is not timely, data accuracy can be lost because fisherman are completing the landings report only once each year, potentially months after fishing occurred, and not all catch and effort data recorded.

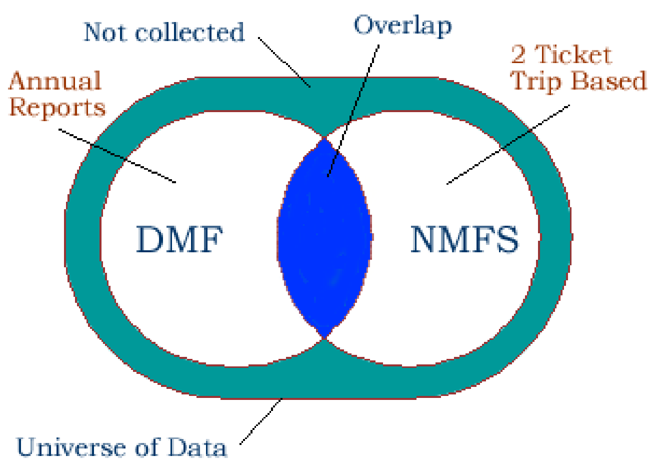
2. **NOAA Fisheries (NOAA's National Marine Fishery Service):** NOAA Fisheries also collects commercial landings and catch and effort data in Massachusetts for a number of years. The emphasis of its data collection efforts center more on vessels which fish in federal

waters and seafood dealers that purchase from these federally permitted vessels. All species and gear types are surveyed, but for federal permit holders only. Data are collected in a trip-based format, featuring a two-ticket system. The vessel completes a vessel trip report (VTR) for each trip and the dealer completes a dealer weigh-out when purchasing from a vessel. NOAA Fisheries also maintains landings information for quota monitored species, although in Massachusetts these data are actually collected by *MarineFisheries* and then passed along to NOAA Fisheries on a weekly basis. Finally, NOAA Fisheries permits only those vessels fishing in federal waters and those dealers that purchase from federally permitted vessels.

Limitations to NOAA Fisheries data collection methods include the fact that 1) only federally permitted vessels and 2) dealers submit reports and unmatched records occur in a two-ticket system (dealers sometimes can't identify vessels and vessels sometimes can't identify dealers).

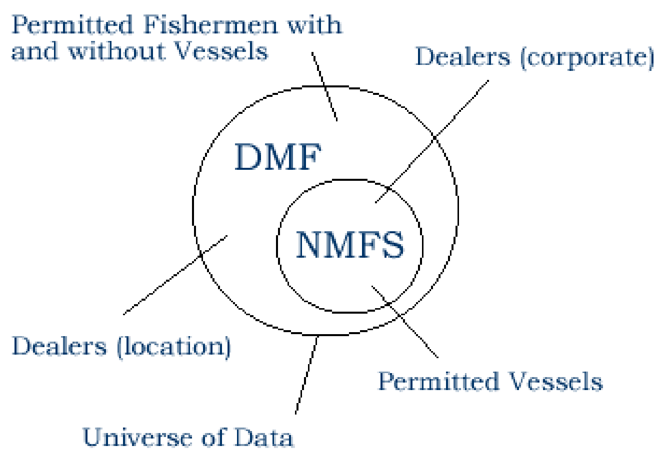
Other Issues Related to Monitoring Commercial Fish Landings: When considering an ACCSP compliant trip-based solution for Massachusetts, there are three other major issues that must be addressed when looking at the current situation:

- *Two independent agencies*. Two independent agencies with existing programs (staff, infrastructure and business processes), data time-lines, difference in data elements, and most importantly, the trust each agency has in one another, exist. If these two agencies are to come together to collect ACCSP compliant data, some major changes will be required by one or, most likely both, to accomplish this.
- *Two agencies collecting both independent and overlapping data*. Not only are the mechanisms different (annual report vs. trip-based; species or gear based report vs. all species and gears report), but also some data collected by each agency *are not* collected by the other, and some data collected by each agency *are* collected by the other. In addition, some data *are not collected at all* by either agency.



MA Commercial Catch & Effort Data

- *Two agencies have permitting systems, again which have both independent and overlapping permit holders*. DMF *MarineFisheries* issues permits to all commercial fishermen, not vessels, whether they fish in federal waters or not. DMF *MarineFisheries* also issues permits to all seafood dealer locations in Massachusetts. NOAA Fisheries on the other hand, issues permits only to vessels that fish in federal waters (which includes vessels that fish in both federal and territorial waters); they do not issue permits to vessels that only fish in state waters. In addition, NOAA Fisheries permits seafood dealers that buy from these federally permitted fishermen. The NOAA Fisheries dealer permit is not associated to the location, but rather the corporation. In other words, a dealer may have several locations in Massachusetts, but NOAA Fisheries only issues one permit to that corporation.



MA Commercial Permits

CURRENT SOLUTION TO MANAGEMENT OF LANDINGS DATA

Given the disparate systems to monitor landings data, how can two agencies continue to collect commercial landings, catch and effort data in Massachusetts while meeting ACCSP guidelines? Furthermore, how can a solution eliminate duplication and impose the least amount of burden on the seafood industry while providing timely, accurate data?

As of November 2003, *MarineFisheries*, NOAA Fisheries, and ACCSP are working towards implementing the following plan, which addresses a change in how landings data are collected. A federal mandate has been issued which requires that all federally permitted dealers report their primary purchases from fisherman starting May 1, 2004. As a result, DMF *MarineFisheries* will host an electronic dealer reporting application (based on ACCSP guidelines), which will allow all dealers in Massachusetts, who are primary buyers of seafood product, to log their purchases from fishermen on line. NOAA Fisheries and ACCSP will receive regular downloads of the data. While the new electronic dealer reporting system will be in place on May 1, 2004, not all primary buyers in Massachusetts will participate immediately for various reasons (no computer, no internet access, using existing accounting software to record landings already, etc.). Indeed, it is likely to take one to two years to bring all dealers on board. A federal grant application has been submitted (approval pending) to fund two new positions within *MarineFisheries* and an Oracle contract to get this project started. However, long-term funds are needed to maintain the project.

Unfortunately, this solution only addresses landings data in Massachusetts; it does not provide a solution for solving the disparity and gaps revolving around catch and effort data from fishermen. The lack of gear and area specific data on data for landings catch and effort that is gear and area specific continues to cause difficulties with assessment and management decisions. Considerable funding and coordination will be required to craft a solution to this problem. Presently, NOAA Fisheries will continue to collect vessel trip reports from federally permitted fishermen, and *MarineFisheries* will continue to collect annual catch reports from select commercial fishermen. Considerable funding and coordination will be required to craft a final solution.

In conclusion, it is clear that the building blocks for ACCSP compliant data collection methodologies are in place. Many years were spent by all Atlantic states and federal agencies planning and building an information system that would store standardized marine fisheries data for the entire Atlantic Coast. The organization (i.e., format of the data and the repository) is in place. The current goal is to have all partners begin contributing data. Currently, some states are doing so, but Massachusetts is not.

The depiction and discussion of long-term trends for these and other species is beyond the scope of this document. Some important species (e.g., cod) are not presented because detailed area data are not collected in state waters via through the current programs. However, the following graphics present the geographic distribution and magnitude of landings by gear type or species in 2002 for Massachusetts (Figures 1-3). These data have been provided to illustrate the type of information collected via the procedures described above. The species and gear types selected are those that are particularly important to the Massachusetts state waters fisheries and for which detailed catch records are available.

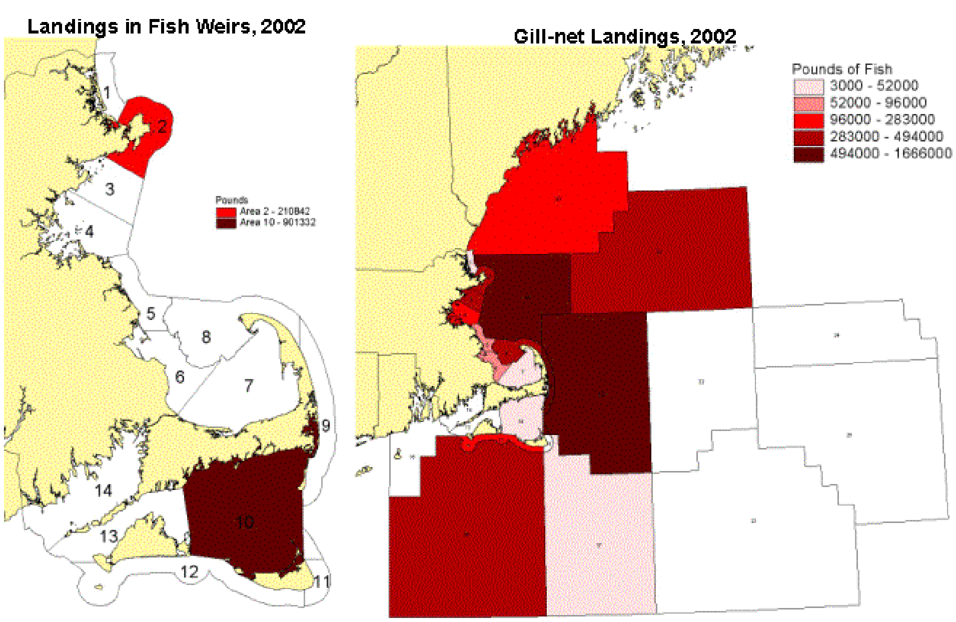


Figure 1. Commercial fish landings from fish weir in state waters and gill-net fisheries from state and federal waters in 2002. Fish weir data shown for Massachusetts waters; gill-net landings shown for state and federal waters.

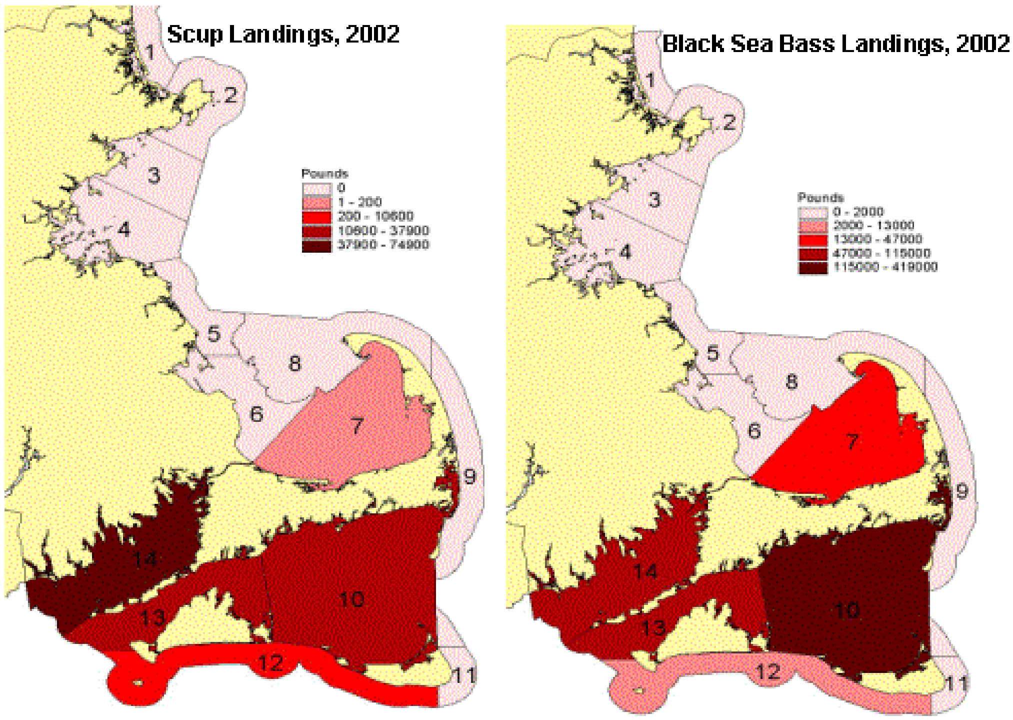


Figure 2. Commercial landings of scup and black sea bass in Massachusetts for 2002.

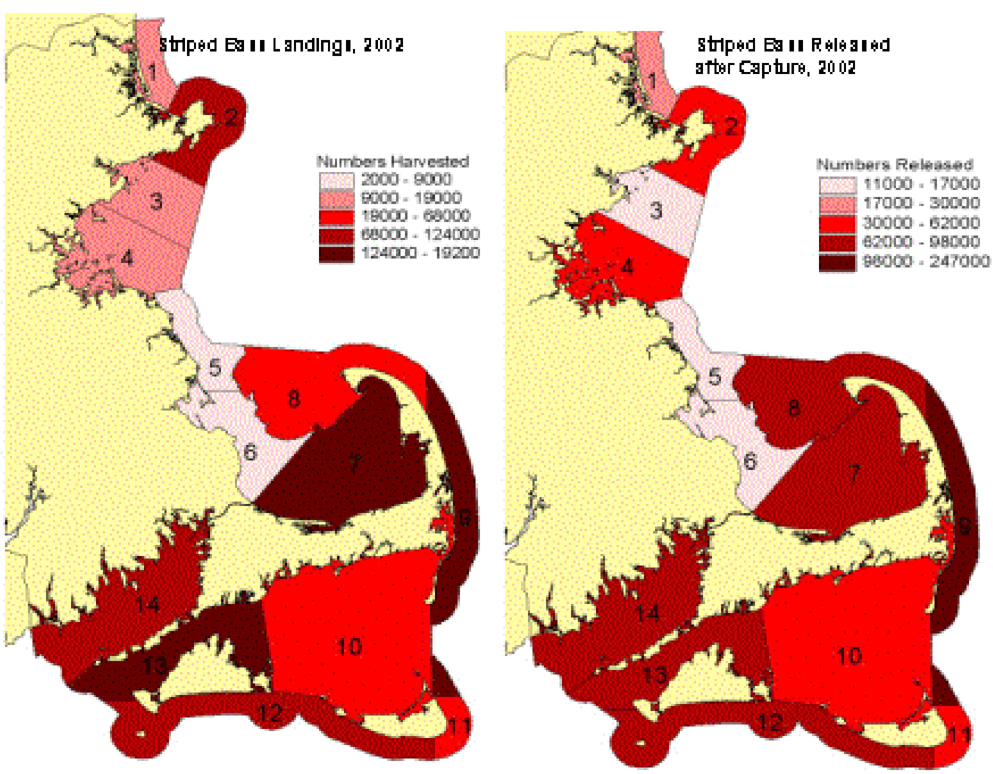


Figure 3. Striped bass landings and release after capture in Massachusetts for 2002.

B. Recreational Fish Landings: Marine Recreational Fisheries Statistical Survey

The Marine Recreational Fisheries Statistical Survey (MRFSS) is a NOAA Fisheries project, jointly funded by the federal and state governments and ACCSP, that provides state-specific estimates of catch and harvest by recreational anglers, number of angler over time, and number of boats over time along the East Coast. Based on field surveys and telephone interviews, these estimates form the basis for many management decisions and are used extensively in stock assessments. In general, the estimated catches positively track the abundance of species. For example, the graph of recreational catches of summer flounder and striped bass reflect the increasing population size for both species (Figure 4).

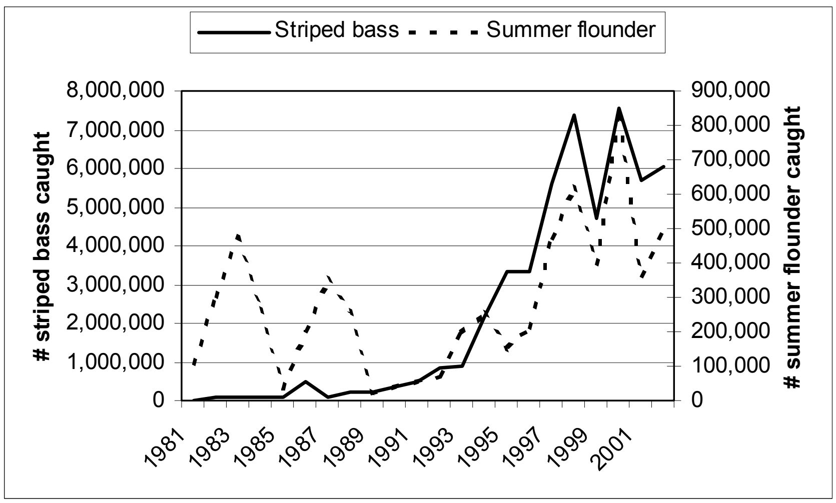


Figure 4. MRFSS estimates of the number of striped bass and summer flounder caught by recreational anglers, 1981-2002.

C. Population Trends for Fishery Species – Fishes and Lobster

The following section describes programs that are in place to monitor population trends in marine and estuarine species. Data presented for selected fishery species is an example of the type of data collected in specified areas (e.g., spring biomass). However, these examples are not a complete assessment of the status of these stocks throughout Massachusetts or throughout the species geographic range. NOAA Fisheries (NMFS) also conducts an extensive stock assessment that incorporates *MarineFisheries* data. The NOAA Fisheries program provides the definitive assessment of US fishery stocks, but these data are not presented in this summary.

The *MarineFisheries* programs target certain species or a suite of species that generally have high economic value and therefore, many species are not represented in these collections. This is a review major of *MarineFisheries* ongoing and previous monitoring projects, including: (1) The Resource Assessment Project – Inshore Bottom Trawl Survey, (2) Winter Flounder Young-of-the-Year Seine Survey, (3) Coastal Lobster Investigations, (4) Nearshore Embayment Studies, (5) Large Pelagic Fishes, and (6) Shellfisheries.

These programs sample a wide variety of vertebrate and invertebrate species but the suite of species sampled are limited to those that are susceptible to the survey gear and area sampled. Thus, there is a paucity of data and trends for many species that inhabit Massachusetts waters.

1) Select Fishes and Invertebrates

MA DMFMARINE FISHERIES RESOURCE ASSESSMENT PROJECT –
INSHORE BOTTOM TRAWL SURVEY

MarineFisheries' Resource Assessment Project (RAP) has conducted bottom trawl surveys of Massachusetts territorial waters in May and September since 1978. This represents the longest state operated trawl survey time-series in the region.

Survey Design

The MA DMF Survey coverage extends from the New Hampshire to Rhode Island borders seaward to three nautical miles including territorial waters of Cape Cod Bay and Nantucket Sound; both areas of special jurisdiction to Massachusetts fisheries management. The Inshore Bottom Trawl Survey objectives are: (1) to determine the distribution and relative abundance of recreationally and commercially important fish species in state waters; (2) to collect biological samples; and (3) to collect physical data including geographic location, depth, and hydrographic information. The waters delineated above are stratified into geographic zones (strata) based on depth and area (Figure 5). Trawl sites are allocated in proportion to stratum area and chosen randomly within each sampling stratum. Sites are occasionally relocated due to concentrations of fixed gear or because of untowable bottom.

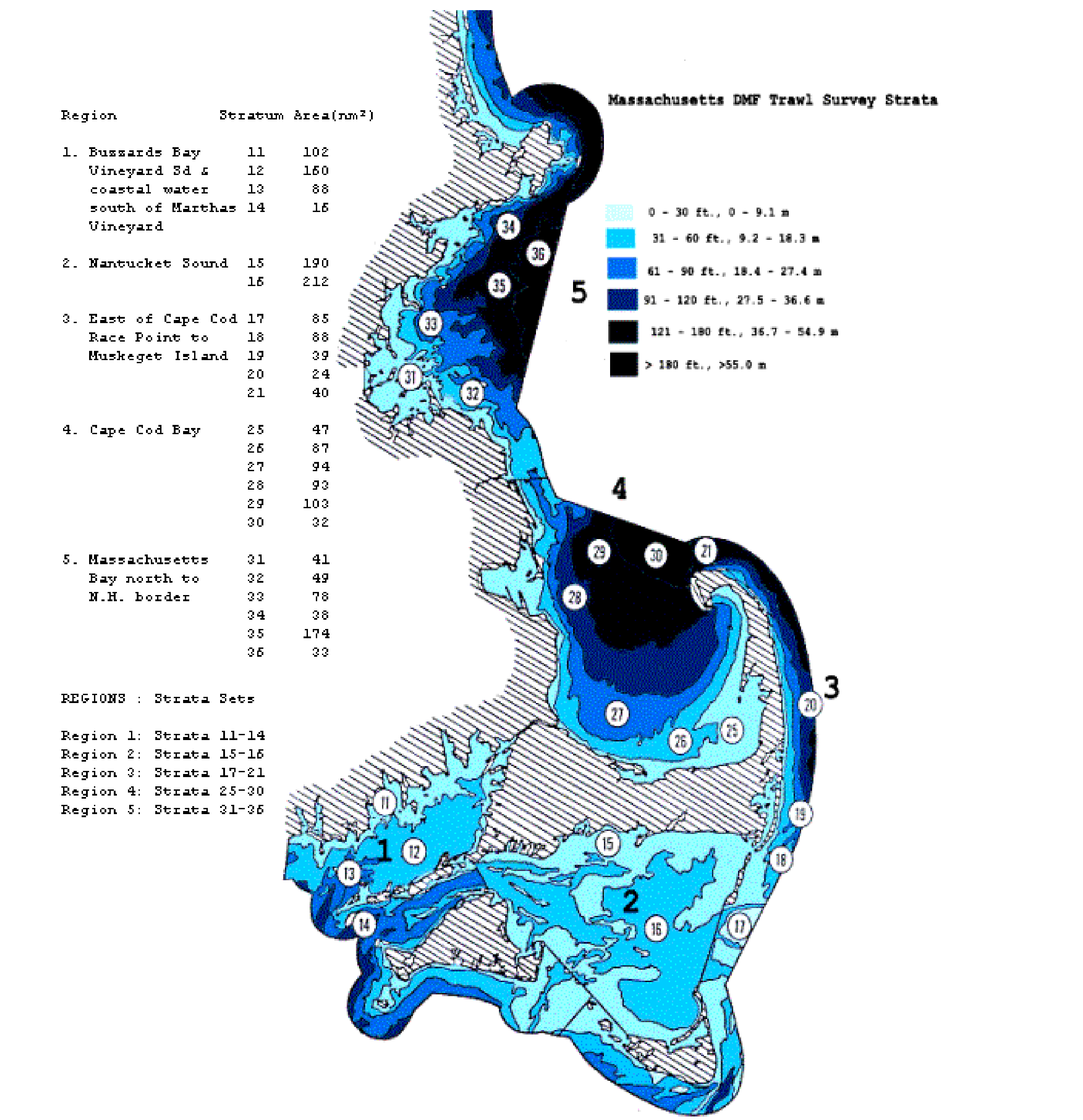


Figure 5. *MarineFisheries* resource assessment project survey design, showing region and depth strata.

A 20-minute tow at 2.5 knots is undertaken at each station with a ¾-size North Atlantic type, two seam otter trawl (11.9 m head rope - 15.5 m footrope). The net is rigged with a 15.5 m chain sweep with 8.9 cm rubber discs; 19.2 m bottom legs of 9.5 mm chain; 18.3 m wire top legs; and, 1.8 x 1.0 m, 147 kg wooden trawl doors. The net contains a 6.4 mm mesh cod end liner to retain small fish.

Standard bottom trawl survey techniques are used when processing the catch. Generally, the total weight (nearest 0.1 kg) and length-frequency (nearest cm) are recorded for each species on standard trawl logs. Age and growth material (hard parts) as well as maturity and pathology observations are collected during the measuring operation. At each station, surface and bottom temperatures and surface salinity are recorded. All of these parameters provide valuable data to examine changes to species abundance and life history characteristics through space and time.

Time Series Trends for Selected Species / Stocks

Figures 6-14 presented illustrate stratified mean weight per tow (kg) + 2 standard errors, 1978 – 2002 for several species whose population is believed to be well represented by the trawl survey. The time period and area(s) represented differ for each graph but represent the time and area of sampling that best tracks the individual population. The median gives a general sense of the population level relative to present and historic (1978) values, but should not be used as a reference for current management targets. Error bars are relatively large in most cases due to the inherent variability of trawl sampling and the abundance and distribution of fish species.

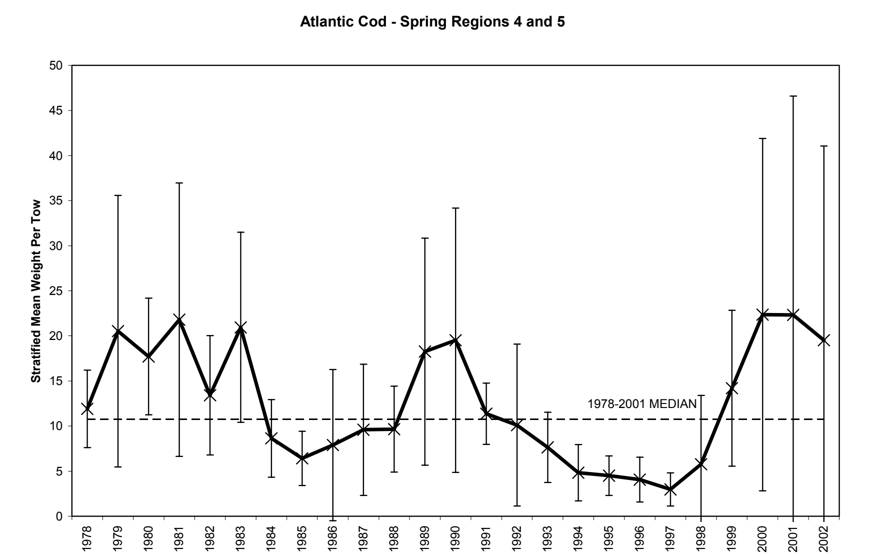


Figure 6. Atlantic cod spring abundance.

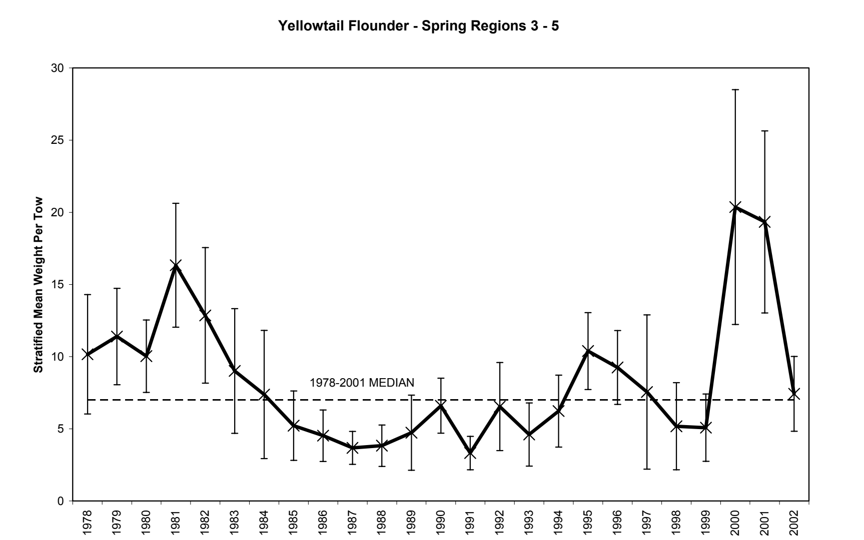


Figure 7. Yellowtail flounder spring abundance.

The MA *MarineFisheries* biomass index of **Atlantic cod**, Gulf of Maine stock (regions 4 and 5 in Massachusetts waters), exhibited relatively high values during the first few years of the time series. The index dropped in 1984 and remained below the median through the mid-1980s, then increased to a relative high in 1989-1990. The index then declined steadily to a time series low in 1997. Since 1997, the index has increased significantly, attaining a time series high in 2000. In 2001, the index remained at a very high level, matching the 2000 high. These highs were followed in 2002 by a slight decline in the index, although it remains at nearly twice the time series median and represents the sixth highest value in the time series.

From the start of the survey in 1978 until the early 1980's the **yellowtail flounder** biomass index for the Cape Cod stock (regions 3-5) remained relatively high. However, a steady decline from a 1981 peak led to 10 years (1985-1994) at or below the time series median. A modest and unsustained increase was seen in the mid 1990s. In 2000, the index increased dramatically to more than three times the median. The 2000 time series high was followed by a slight decrease in 2001 but the index remained well above the median. A significant decrease was seen in 2002, with the index declining to a value very near the time series median.

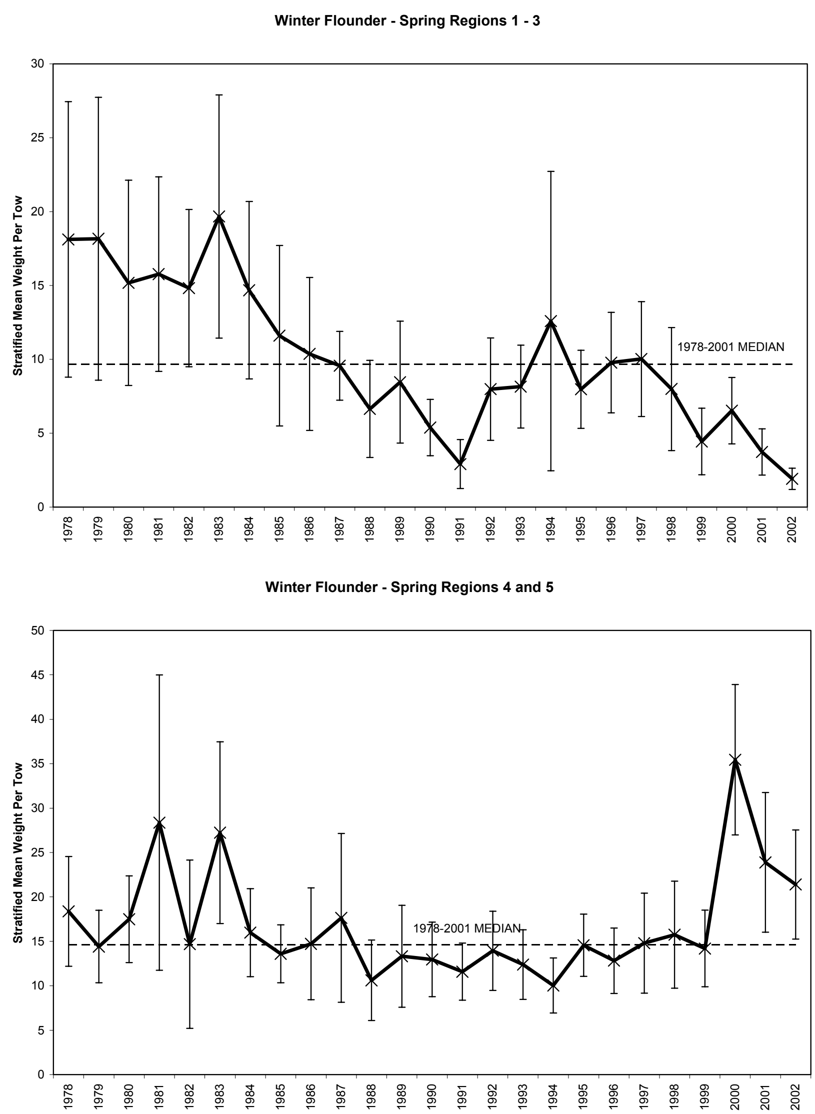


Figure 8. Winter flounder spring abundance.

The **winter flounder** index for the southern New England stock (regions 1-3) was at a high level from 1978-1983 before declining, almost uninterrupted, to lows in the late 1980's and early 1990s. Through the mid-1990s the index fluctuated around the median. In the late 1990s through 2001, the biomass indices declined to values similar to lows recorded a decade earlier. This decline continued in 2002, with the index reaching the lowest value seen in the time series.

For assessment purposes, the *MarineFisheries* MA DMF **winter flounder** biomass index for regions 4-5 is the *de facto* fisheries independent estimator for Gulf of Maine winter flounder. Spring biomass values decreased after 1983. The index remained at or below the median with no perceptible trend from 1988 through 1994. A slight increasing trend in the latter half of the 1990s was followed by a dramatic rise to a time series high in 2000. In 2001, the index dropped from the record of 2000 but remained higher than any of the previous sixteen years. The index continued to decline in 2002, yet remained well above the median, and represents the fifth highest index in the time series.

The spring **black sea bass** index (regions 1-3) was high from 1978-1983 then declined to record-lows from 1992-1998. The biomass remained below the median from 1987-1998 followed by an increase to a record high in 2000. The index declined somewhat in the subsequent two years, but remains well above the median. The three terminal years, 2000-2002, combined to produce the highest 3-yr average in the time series. The *MarineFisheries* biomass trend agrees with Massachusetts landings over the past decade (Caruso 2002).

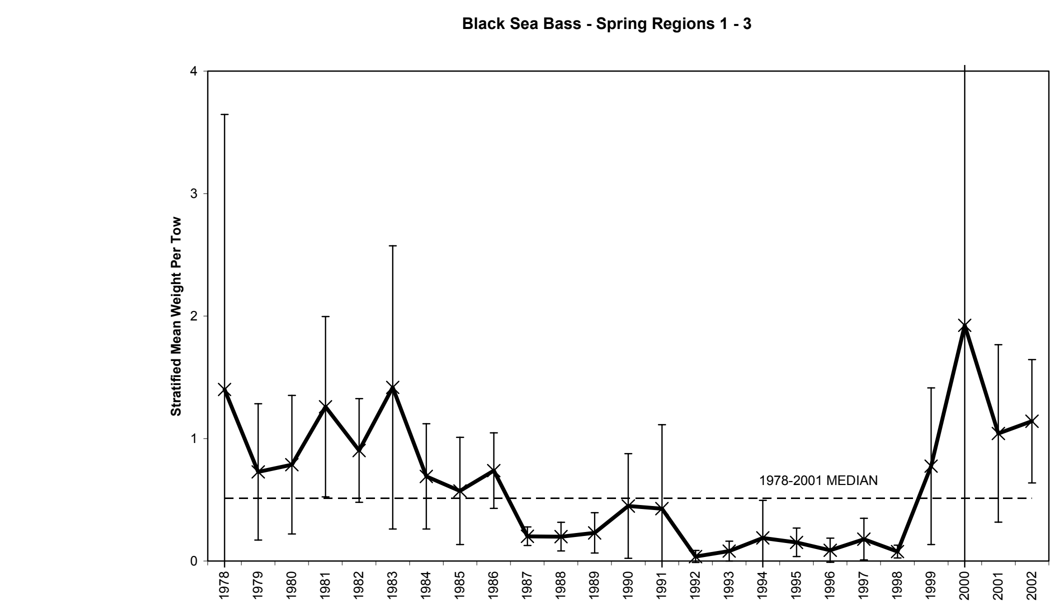


Figure 9. Black sea bass spring abundance.

The spring **tautog** index (regions 1 – 2) exhibited an increasing trend in the early years of the survey, culminating in a time series high in 1986. The index then declined over the next few years, dipping below the median in 1990. The index has remained at low levels since that time and has been well below the median since 1992.

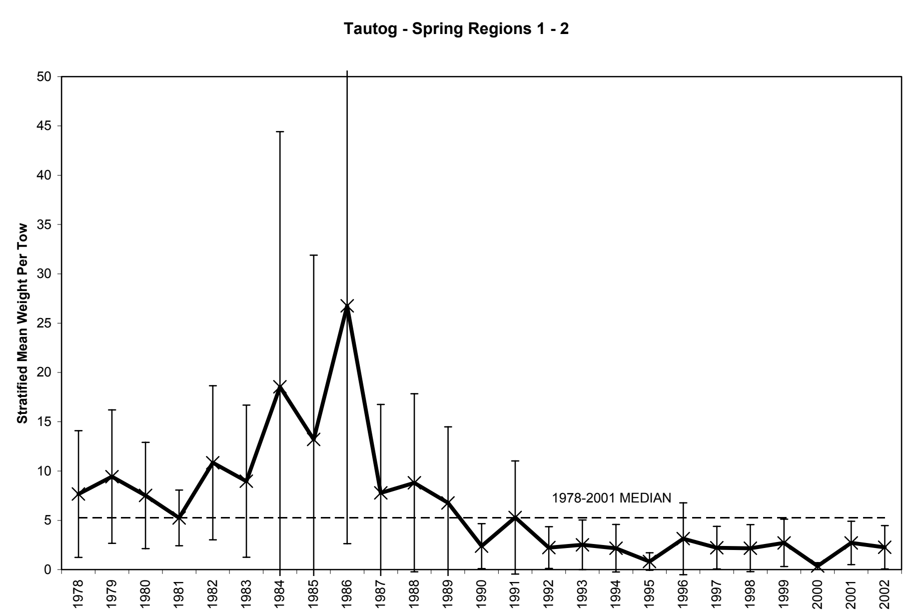


Figure 10. Tautog spring abundance.

The spring **summer flounder** biomass index (regions 1 - 3) declined after 1982. For a period of eight years (1986-1993), the index remained below the median and a time series low was measured in 1991. Since that time, the index has generally exhibited an increasing trend. In eight of the past nine years (1994-2002), the biomass index has been above the median. Following a relative low in 1996, the index rose steadily to a record high in 2000. The 2001 index declined over 30% from 2000 yet was still one of the highest values in the time series. A slight increase was seen in 2002 with the index representing the second highest in the survey time series (more than two times the median). The recent *MarineFisheries* index trend mirrors that of the NEFSC spring survey and, over the time series, resembles the trends in spawning stock biomass derived for the Middle Atlantic-Georges Bank stock region (NEFSC 2000).

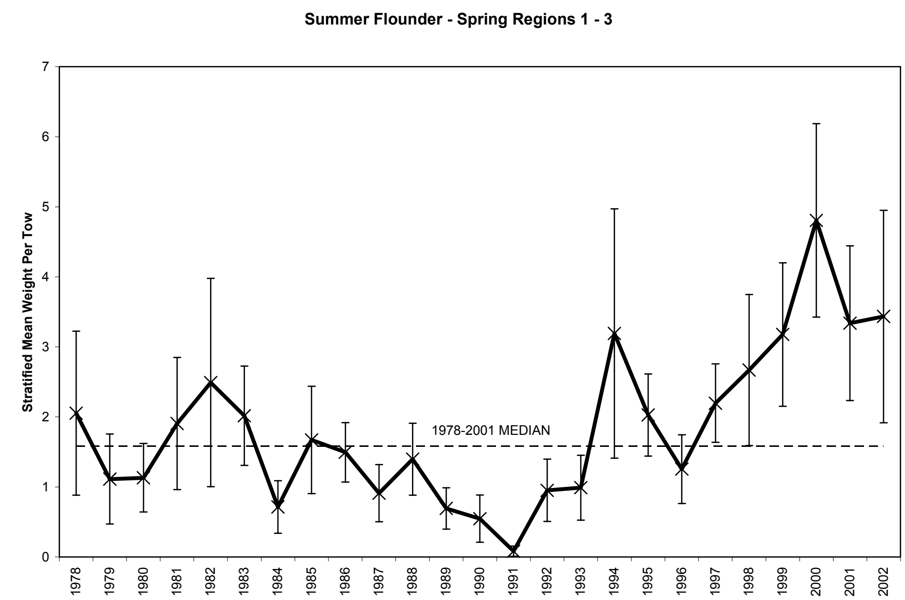


Figure 11. Summer flounder spring abundance.

The **long-finned squid** index (spring, regions 1 - 3) reveals a period of relatively low and variable biomass from 1978-1982 followed by nine years in which the index remained above the median (1982 – 1991). For the past decade, the index has remained at low levels, with nine of the past eleven years below the time series median.

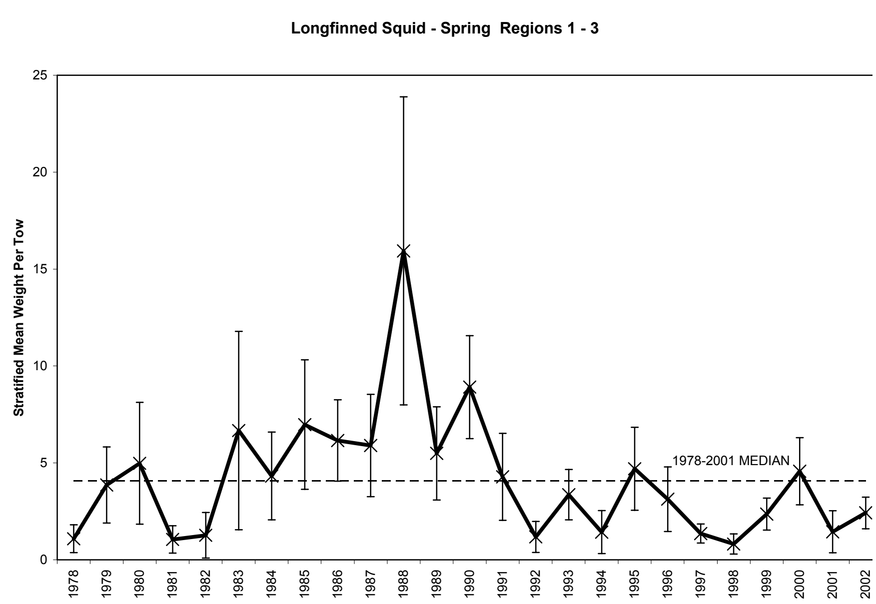


Figure 12. Long-finned squid spring abundance.

The spring **scup** biomass index (regions 1-3) was at its highest values in the early years of the survey time series (1978-1981). From 1982 to the present, the index has remained significantly lower except for single year highs in 1990, 2000 and 2002. A decline from a relative high in 1990 to record lows from 1996-1998 is apparent. This decline has been followed by more variable (and generally greater) catch rates in recent years. The 2002 index was more than five times the median and represents the sixth highest value in the time series.

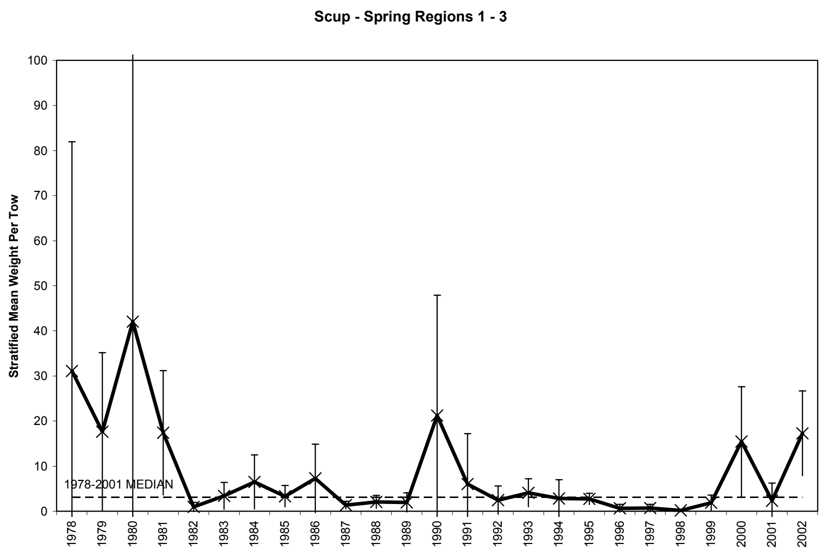


Figure 13. Scup spring abundance.

Butterfish are captured in great numbers during autumn surveys in state waters south of Cape Cod (regions 1 and 2). The bulk of the biomass captured represents recent year classes (ages 0 and 1) with few older fish present in catches. Therefore, this index may serve as an indicator of year-class strength as well as stock biomass. The autumn butterfish index has varied greatly over the time series, with periods of high biomass interspersed with periods of low biomass. The early years of the survey are characterized by relatively low biomass levels. From the late 1980's through the late 1990s the index exhibited a general increasing trend

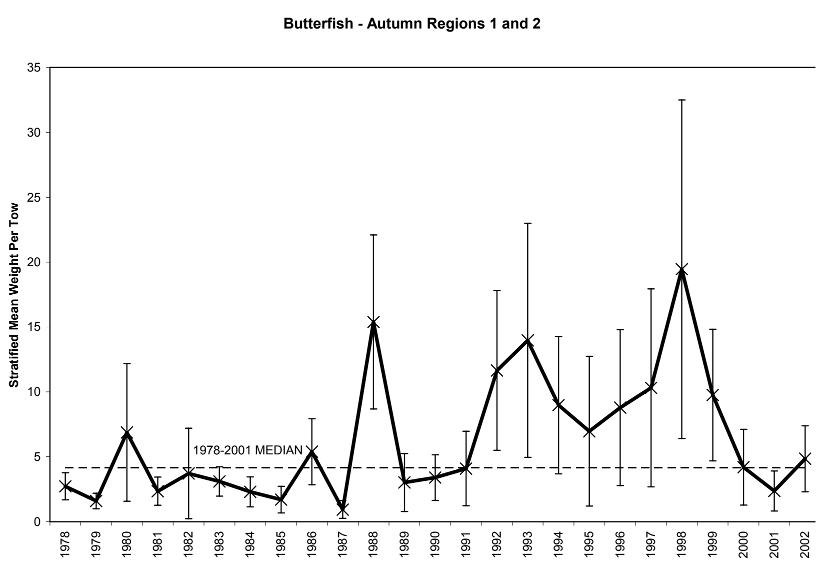


Figure 14. Butterfish fall abundance.

with the majority of years above the median. This increase led to a time series high in 1998. This high was followed by a dramatic decline to values near the median. The terminal year shows a slight increase in biomass.

Limitations of the RAP Trawl Survey

- Seasonality – The RAP survey samples only those species available in May and September.
- Habitat – Due to the nature of the sampling gear, "hard bottom" habitat is undersampled.
- Habitat utilization – The data provide little information concerning species abundance as it relates to habitat type.
- Species represented – The RAP survey gear does not sample pelagic and semi-pelagic species well, and other fish species have low catchability related to the sampling gear.
- Estuaries/nearshore – Due to vessel size, very shallow water (< 7 meters) is not well sampled.

WINTER FLOUNDER YOUNG-OF-THE-YEAR (YOY) SEINE SURVEY

Since 1975, *MarineFisheries* has conducted a seine survey of six Cape Cod south shore estuaries (Bass River, Cotuit Bay, Great Pond, Lewis Bay, Stage Harbor, and Waquoit Bay) during the months of June and July. The survey's primary objective is to assess winter flounder YOY cohort abundance (i.e., the southern stock). The survey also enumerates YOY summer flounder and 'brit' (juvenile) Atlantic herring since both data sets are monitored by assessment working groups as potential predictors of recruitment. Preliminary sampling efforts also included Buzzards Bay and areas north of Cape Cod; however, these stations were discontinued due to insufficient agency resources.

Survey Design

Seining of intertidal and shallow subtidal zones occurs from two hours before to two hours after high tide. Forty-nine stations, chosen for efficient seining (i.e., smooth sediment bottom generally devoid of attached vegetation) and historic availability of YOY (also categorized as 0-group) winter flounder, were proportionately allocated by each estuary's (stratum) littoral perimeter. A 6.4-meter straight seine of 6.4 mm nylon meshes and equipped with weighted lead line footrope is hauled perpendicular to shore from depths of up to approximately 1.2 meters. To enumerate 0-group winter flounder density (# YOY per square meter), three replicate hauls at each station are quantified to area swept by maintaining a taut spreader rope, and pacing seining distance.

Statistical analysis of the seine data employs stratification techniques; each estuary is considered a stratum, and the three replicate hauls at each station are treated as one sample. Stratified mean density and confidence limits are derived from standard and modified formulas for mean and variance.

Time-Series Trends of YOY Winter Flounder

The seine survey index for YOY winter flounder exhibits considerable variability from year to year, although trends are apparent in the time-series. During the early years of the survey, the mean catch per tow was generally at or above the time-series median, with a number of years well above the 75th percentile. In the 1980's the index generally tracked close to the median. During the last decade the index indicates generally low recruitment, with seven of the last 10 years below the median and six of those years falling below the 25th percentile.

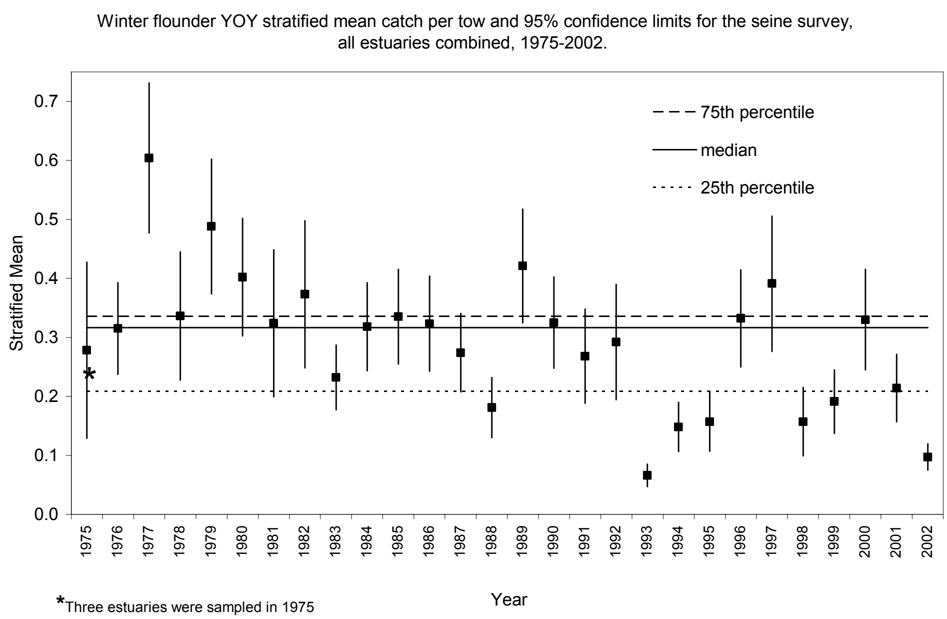


Figure 15. Mean catch per tow for the YOY winter flounder seine survey.

<u>Limitations of the YOY seine survey</u>

- Species – This is primarily a single species survey and provides little information on other important estuarine species.
- Geographic Coverage – Due to manpower limitations, only six estuaries are sampled. There are numerous others with potential for significant production of YOY winter flounder, which could potentially influence the index.

2) Coastal Lobster Investigations

MarineFisheries' Coastal Lobster Investigations Project employs a comprehensive four-tier approach to monitoring lobster populations in Massachusetts coastal waters. This approach includes two fishery dependent monitoring programs, the Massachusetts Coastal Commercial Lobster Trap Sampling Program and Lobster Fishery Statistics Program, as well as two fishery independent programs, the Inshore Bottom Trawl Survey (described in previous section) and the Early Benthic Phase (EBP) Suction Sampling Survey.

COMMERCIAL LOBSTER TRAP SAMPLING PROGRAM and MASSACHUSETTS LOBSTER FISHERY STATISTICS

Initiated in 1981, the Commercial Lobster Trap Sampling Program was and is the cornerstone of monitoring lobster populations in Massachusetts coastal waters. The program is a cooperative effort between commercial lobster fishermen and *MarineFisheries* designed to collect biological and catch per unit effort data with sufficient precision for stock assessments. Sampling is carried out twice a month from May through November, coast-wide in each of six regions (Figure 16), during the normal lobstering operations of volunteer commercial lobstermen.

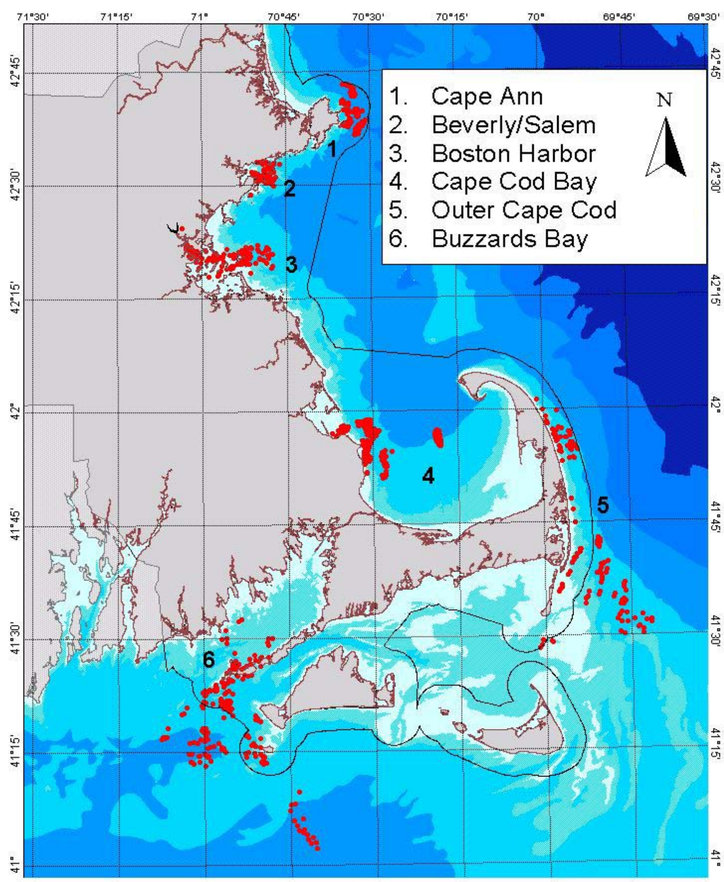


Figure 16. Map of coastal Massachusetts with trap/trawl locations sampled in 2002 throughout six sampling regions.

Sea samplers use portable cassette tape recorders to record carapace length (to the nearest mm), sex, and condition, including the degree of shell hardness, culls and other shell damage, external gross pathology, mortality, and presence of extruded ova (eggs) on females (ovigerous) for every lobster that is caught. Catch in number of lobster, number of trap hauls, set over days, trap and bait type are also recorded. Since the early 1990s, *MarineFisheries* has also monitored the prevalence and spatial distribution of lobster shell disease. Trap locations are recorded from LORAN/GPS instruments on each vessel and plotted on nautical charts. Depth information is estimated from NOAA navigational charts as a coast-wide standard to avoid variability from tidal fluctuations. Data generated from this program are utilized as an integral part of the ASMFC stock assessment process, specifically for calculating fishing mortality rates and egg per recruit estimates.

In 2002, the coast-wide mean catch per unit effort index (catch per trap per three set over days; CTH'3) of 0.823 marketable lobster per trap was 3.8% higher than the time series mean of 0.793. Total Massachusetts commercial landings, 13,373,809 lbs, increased by 9.8% from 2001. Landings from territorial waters, 8,083,603 lbs, increased by 13% from 2001 (Figure 17). The coast-wide mean catch rate of sublegal lobster, 0.23 lobsters per trap haul, is the third lowest in the time series, and has remained below the time series mean (0.489) since 1994. It should be noted that escape vent sizes increased during this period, which may in part account for the reduced catch of sublegal lobster.

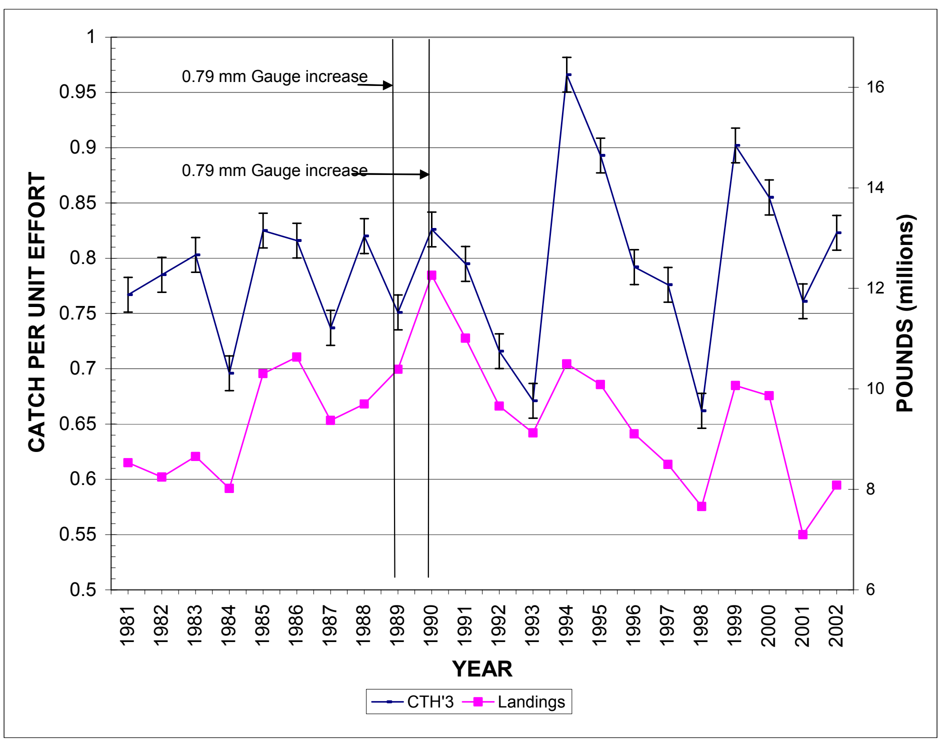


Figure 17. Catch per unit effort (catch per trap per three set over days; CTH'3) of marketable American lobster fro commercial trap sampling and Massachusetts lobster landings from territorial waters, 1981 - 2002.

Historical landings data in Massachusetts provide a perspective on the current condition of the fishery and recent catch trends (Figures 18 and 19). Annual Massachusetts coastal landings (excluding data from beyond territorial waters), which were available only in number of lobster between 1888 and 1921, generally declined between 1888 and 1917 then gradually increased through 1921 (Figure 18). Subsequent landings, available in lbs., doubled over the 52-year time span between 1922 and 1974. Major increases in traps and landings occurred between 1975 and 1990. These trends in landings were primarily a reflection of nominal fishing effort (total traps fished); however, they cannot be attributed to greater fishing effort alone. Total lobster landings and effort from all lobster harvesting states also increased between the late 1970s and 1990s; however in the Canadian Maritimes, where trap limits and license restrictions exist, landings also increased implicating an environmental influence on lobster abundance.

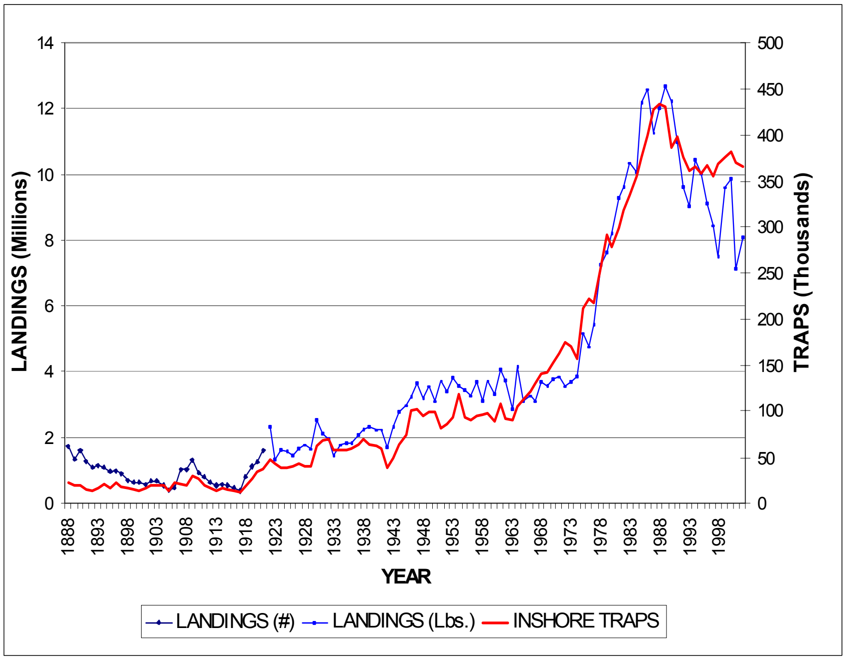


Figure 18. American lobster landings and traps fished from Massachusetts territorial waters, 1888-2002. Data are from MA Lobster Fishery Statistics Program.

Since 1990, Massachusetts inshore lobster landings have declined dramatically and while nominal effort has also decreased, the close correlation evident through the early 1990s has not been maintained.

The average annual pounds per trap (annual landings/total traps fished) experienced a steep decline in the Massachusetts inshore fishery from the beginning of the time series until the early 1900's. Through the first half of the 1900's the annual catch per trap varied without trend, but underwent another significant decline in the 1960's (Figure 19). Between 1970 and 2002 this index ranged between 20 and 30 lbs. per pot, with the two lowest values in the time series (20.4 and 19.3 lbs. per pot) occurring in 1998 and 2001 respectively.

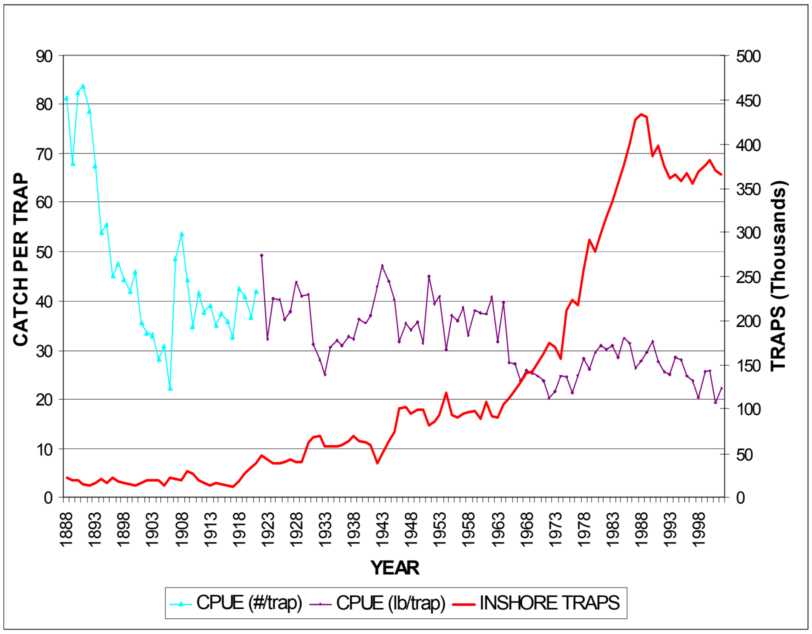


Figure 19. Traps fished and catch/trap data from Massachusetts territorial waters, 1888-2002. Data are from MA Lobster Fishery Statistics Program.

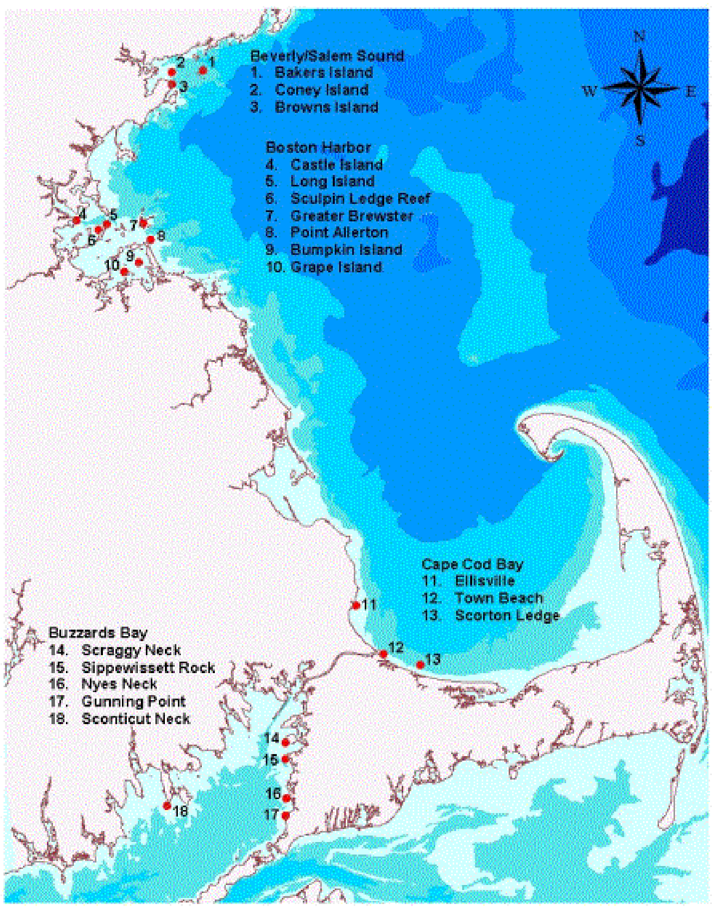


Figure 20. *MarineFisheries* EBP sampling station locations along the coast.

EARLY BENTHIC PHASE LOBSTER MONITORING

An annual sampling effort for Early Benthic Phase (EBP) or juvenile lobsters is conducted by SCUBA through suction sampling of 1/2 square meter plots in order to generate density indices of newly-settled post-larval lobsters (1995 to present) and larger juveniles, and to delineate coastal habitat important to the settlement of these juveniles, in particular cobble bottom. Work is conducted annually in four coastal regions (Figure 6), off Salem (3 sites), Boston (7 sites), Cape Cod Bay (3 sites), and Buzzards Bay (5 sites). Other macro-invertebrates (i.e., crabs) encountered are enumerated through this effort.

MASSACHUSETTS RESOURCE ASSESSMENT PROJECT INSHORE BOTTOM TRAWL SURVEY – LOBSTER ABUNDANCE INDICES

Southern Gulf of Maine (MA southern GOM): Relative abundance trends from *MarineFisheries'* inshore bottom trawl surveys indicate that catch per unit effort (CPUE) has declined to a level similar to that observed in the early 1980's or lower. The 2001 MA southern GOM fully-recruited (83+mm carapace length, CL) lobster indices were well below their respective time series means, and were close to the lowest values in the 21-year time series for both males and females. The 2001 MA GOM pre-recruit (71-82mm CL) lobster indices were well below their respective time series means, and were the second lowest values in the 21-year time series for both males and females. The 59-70 mm CL size group followed a similar trend for both sexes.

Southern New England: The 2001 Massachusetts Southern New England fully-recruited (83+mm CL) lobster indices were well below their respective time series means for both males and females. The pre-recruit (71-82mm CL) indices, declining since 1991, were near time series lows, and have remained well below that observed in the late 1980's and early 1990s for both sexes. The 59-70 mm CL size group followed a similar trend for both sexes, peaking in 1993 then declining thereafter.

BOTTOM WATER TEMPERATURE MONITORING

In conjunction with the coastal lobster monitoring investigations, *MarineFisheries* has monitored bottom water temperature from 1982 to present. Water temperature is collected with programmable electronic recorders at various depths at nine coastal sites located north and south of Cape Cod. *MarineFisheries* is concerned with the impact of increasing water temperatures on lobster along the Massachusetts coast. Conclusions on the effect of temperature on lobster abundance are yet to be determined. See Water and Sediment Quality Technical Report for further description.

3) Nearshore Embayment Studies of Marine Resources

During the 1960's and 1970's, *MarineFisheries* conducted a series of studies in the sixteen major embayments along the Massachusetts coast. These studies were designed to characterize the living resources within each embayment with an emphasis on finfish, decapod crustaceans, and commercially-important shellfish. The embayments covered include: Merrimack River, Parker River-Plum Island Sound, Gloucester Harbor-Annisquam River, Beverly-Salem Harbor, Lynn-Saugus Harbor, Dorchester Bay, Quincy Bay, Hingham Harbor, North River, Plymouth-Duxbury Bay, Wellfleet Harbor, Pleasant Bay, Bass River, Waquoit Bay-Eel River, Westport River, and Taunton River-Mt. Hope Bay.

One of the more noteworthy results of this effort was the illustration of the tremendous biodiversity of estuarine fauna found along the Massachusetts coast. Over the last 30-40 years, these reports have provided a great deal of information for management of our coastal resources and the review of coastal alteration projects. In many cases, they remain the only source of information regarding living marine resources in specific areas. While they continue to be very valuable sources of information, that information is now outdated because of changes in the living marine resources resulting from changing land and water use, exploitation of many fish and shellfish species, and natural population fluctuations. Due to budget and personnel constraints within *MarineFisheries*, only one of these studies has been repeated by *MarineFisheries*. The study of Beverly-Salem Harbor was updated in 1997 and has been published in the *MarineFisheries* Technical Report Series (No. TR-6). This study documented a number of changes that have occurred in this estuary, notably a general improvement in the condition of the area and a change in the rank abundance for several species. *MarineFisheries* assisted the Office of Coastal Zone Management study fishes and decapod crustaceans in Gloucester and New Bedford Harbors and Massachusetts Audubon investigated the marine resources of the Parker River – Plum Island Sound estuary. Although the CZM and Massachusetts Audubon studies are not directly comparable to the 1960's and 1970's studies, they provide the first comprehensive examination of marine resources in these embayments since the initial assessments.

It is critical that these studies be repeated in all of Massachusetts important embayments, so that they may once again serve as a primary source of information for responsible management of Massachusetts coastal living resources.

4) Anadromous Fish

MarineFisheries informally monitors the spawning runs of anadromous fishes in Massachusetts in over fifty separate locations through direct observation and through information provided by local officials and watershed groups. *MarineFisheries* staff directly enumerate fish at several locations using a variety of methods including electronic counters and visual counts. The longest time series of information is available for the Herring River in Bournedale (Figure 21) and for the Merrimack River in Lawrence (Figure 22). The river herring population in the Herring River has shown wide fluctuations with declines in 2002 and 2003. In the Merrimack River, the river herring run has declined in recent years but the American shad population has increased dramatically.

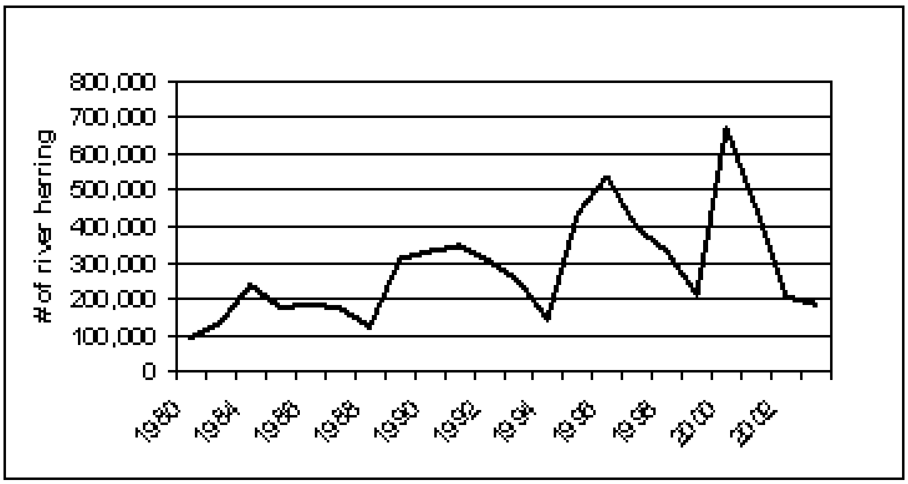


Figure 21. River herring counts on the Herring River, Bournedale, MA.

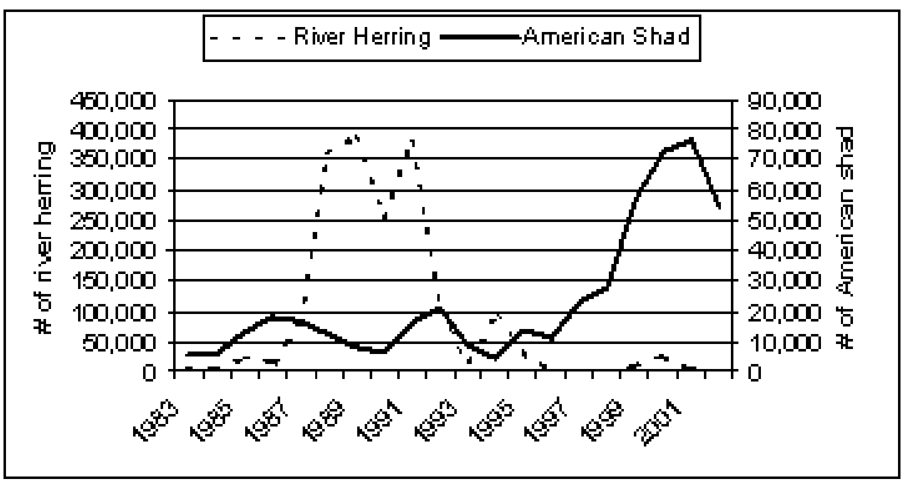


Figure 22. River herring and American shad counts on the Merrimack River.

The Anadromous Fish Program also monitors and maintains the function of fish passage structures throughout coastal Massachusetts. A recent survey of fish passage (Massachusetts Division of Marine Fisheries Technical Reports TR-15 through TR-18) recorded 175 fish passage structures and over 100 separate runs of anadromous fish. Historically, anadromous fish were eliminated from most of the coastal rivers and streams. Through stocking and fishway construction over the last 50 years, *MarineFisheries* has restored anadromous fish populations to many of our coastal water bodies. Continued restoration of the anadromous fish resource will require extensive repairs and maintenance to existing infrastructure as well as continued stocking, research, and fishway construction.

5) Tournament Monitoring of Large Pelagic Fishes

The highly migratory nature, large size, and long life span of species such as bluefin, yellowfin, albacore, and bigeye tunas, blue, mako, and thresher sharks, and blue and white marlin render data acquisition and biological studies that are expensive and difficult to execute. Consequently, recreational fishing tournaments have been used as a tool by *MarineFisheries*' biologists to learn about the species and size composition, basic biology, and relative abundance of big game fishes off our coast. Offshore fishing tournaments not only provide catch data and biological samples but estimates of effort, which are often lacking for offshore recreational fisheries. Although the number of tournaments held in Massachusetts fluctuates from year to year, there are generally eight to eleven, with most located on the Cape and Islands. While some target a single species or type of fish, like sharks or giant bluefin tuna, most tournaments offer prizes for a variety of species. All the events self-impose minimum sizes and bag limits (i.e., maximum number of fish landed allowed) while promoting tag and release, so points can be garnered by not only weighing fish but by also releasing them.

Although tournament data are traditionally used by the federal government to monitor landings in offshore recreational fisheries, the Massachusetts Tournament Program is unique. The *MarineFisheries* program makes every effort to collect total catch information, which includes not only fish that are landed but also those that are tagged, released, or lost. By working closely with tournament sponsors and tournament participants, *MarineFisheries* biologists not only assist in the development of the event but also facilitate complete data collection. This is particularly important when indices of abundance are used to monitor annual changes in fishing success.

The fishing effort collected at each tournament are used to calculate catch per unit effort or CPUE. For tournament fishing CPUE is defined as the number of fish caught for each hour fished. Dramatic fluctuations in CPUE may be indicative of changes in regional fish abundance caused by corresponding changes in prey availability, fish population size, or the environment. Program personnel analyze long-term trends in CPUE and summarize these findings in an annual program report.

The Massachusetts Sportfishing Tournament Monitoring Program also collects catch data at the month-long Martha's Vineyard Striped Bass and Bluefish Derby. These data allow for the delineation of trends in the inshore abundance of striped bass, bluefish, false albacore, and Atlantic bonito. The comprehensive catch and effort data collected by the Tournament Program are forwarded annually to the National Marine Fisheries Service for inclusion in their national statistics.

Sharks in the coastal waters of Massachusetts

MarineFisheries established the Massachusetts Shark Research Program (MSRP) in 1989 to characterize the ecology, distribution, and relative abundance of sharks subjected to fisheries off the coast of Massachusetts. The MSRP conducts angler and longline surveys and collects information from recreational and commercial fishers. Biological parameters including age structure, feeding ecology, local movements, and reproductive status are examined through dissection and tagging of shark specimens. Additionally, information has been compiled and analyzed for the identification of primary and secondary shark nursery habitat in the coastal waters of Massachusetts.

The Massachusetts coastline is divided by Cape Cod into two general areas relative to shark nursery habitat. The major coastal water masses south of Cape Cod include Buzzards Bay, Vineyard Sound, and Nantucket Sound, while Cape Cod Bay and Massachusetts Bay are the major coastal water bodies north of Cape Cod. This landmass represents the northern limit to the geographic range of a few coastal shark species, which include the smooth dogfish (*Mustelus canis*), sandbar shark (*Carcharhinus plumbeus*), dusky shark (*Carcharhinus obscurus*) and tiger shark (*Galeocerda cuvieri*). While a number of species are found seasonally both north and south of Cape Cod, those penetrating inshore waters include spiny dogfish (*Squalus acanthias*), sand tiger (*Carcharias taurus*), great white (*Carcharodon carcharias*), and basking (*Cetorhinus maximus*) sharks.

Smooth dogfish, *Mustelus canis*

From 1989 to 2002, the MSRP examined 540 smooth dogfish caught by the longline (337) and angler (82) surveys, taken during other *MarineFisheries* sampling programs (82), and provided by commercial fishermen (39). These sharks were mostly sampled from the neritic waters of Chappaquiddick Island and Cape Poge Bay (424), but samples also came from other parts of Nantucket Sound. The size range of all smooth dogfish sampled by the MSRP was 27.5-121 cm fork length (FL; Figure 23). Based on published estimates of size at birth and size at maturity, the smooth dogfish sampled from Massachusetts waters comprised primarily newborns and adults. In the northern end of its range, the smooth dogfish moves into the neritic waters of Nantucket Sound, Vineyard Sound, and Buzzards Bay and associated estuaries in late May and early June to give birth. These areas,

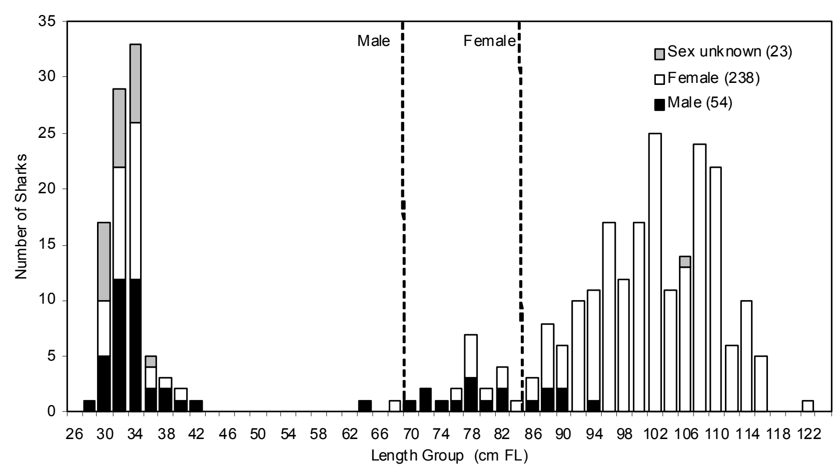


Figure 23. Length frequency distribution of smooth dogfish, *Mustelus canis*, sampled by the MSRP, 1989-2002; size at sexual maturity shown for each sex (dotted lines).

therefore, provide important primary nursery habitat for this species. Based on the size of neonates and time of capture, it is likely that parturition (birth) occurs in June and July in Massachusetts waters. *Mustelus canis* is a seasonal migrant and generally remains in inshore Massachusetts waters until October when it moves offshore and south.

Sandbar shark, *Carcharhinus plumbeus*

During the period of 1989 to 2002, 235 (88 males, 63 females, 84 unknown) sandbar sharks were examined or reported to the MSRP (Figure 24). Although sandbar sharks were taken between 21 June and 2 October, the species was most abundant in July. The size range of those sharks measured was 61-157 cm FL with no sexual differences (Figure 24). With a size at maturity of 143 cm FL and 149 cm FL for males and females, respectively, only 5% of the males and 2% of the females sampled over the 13-year period were mature. Thus, the majority of sandbar sharks occurring inshore are juveniles utilizing these areas as secondary nurseries. Sandbar sharks move out of Massachusetts coastal waters in early October, which likely coincides with seasonal cooling of inshore waters.

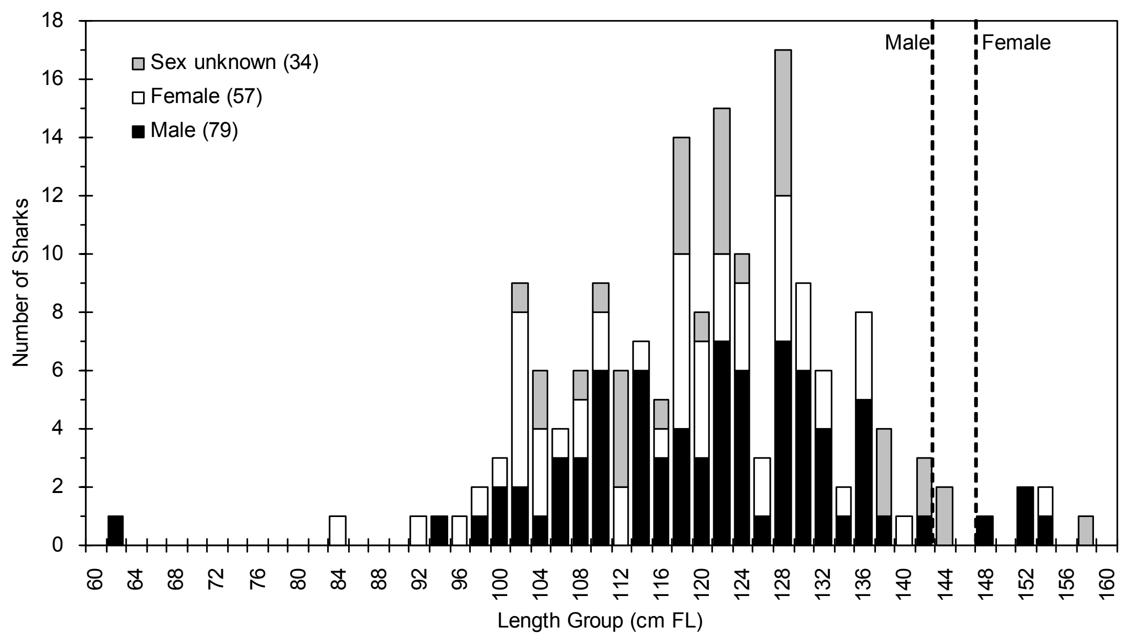


Figure 24. Length frequency distribution of sandbar sharks, *C. plumbeus*, sampled by the MSRP, 1989-2002, size at sexual maturity shown for each sex (dotted lines).

Dusky shark, *Carcharhinus obscurus*

From 1989 to 2002, only five dusky sharks have been sampled by the MSRP and these were taken on longline. Of the four reliably measured, three (two females, one male) were in the size range of 173-183 cm FL and one female was 254 cm FL. The three smaller *C. obscurus* were immature and the larger female had reached maturity. Although there are published reports of dusky sharks from Massachusetts coastal waters south of Cape Cod, the species is not common in southern New England. Nonetheless, this region may provide secondary nursery habitat to those dusky sharks that venture north.

Sand tiger shark, *Carcharias taurus*

Ten sand tiger sharks have been reported to the MSRP since 1989 and all were caught from August to October. The sand tiger shark was once considered the most abundant large shark in Massachusetts coastal waters; it was exploited in Nantucket Sound in the early 20th century. Not a single adult sand tiger shark has been reported to the program since its inception in 1989, despite the extensive commercial and recreational fisheries (for other species) in this state. This provides evidence that intensive commercial fisheries can lead to the long-term depletion of local shark populations. The ten sand tiger sharks examined by the MSRP were reported from two general locations in coastal Massachusetts: south of Cape Cod in coastal waters off East Beach, Chappaquiddick Island (Martha's Vineyard) and from bays and estuaries in Massachusetts Bay (Salem Sound and Boston Harbor). All of these were small immature sand tigers in the size range of 87-132 cm FL; the five sexed were all female. In the western North Atlantic, the sand tiger gives birth from December through March and the average length at birth is 85.3 cm FL. Thus, five of the sand tigers sampled by the MSRP were 87-91 cm FL, close to or in their neonatal stage. These data indicate that the coastal waters of Massachusetts provide secondary nursery habitat for sand tiger sharks that move north from southeastern pupping grounds (habitat for juvenile sharks).

Great White Shark, *Carcharodon carcharias*

The great white shark is a seasonal migrant to the coastal and offshore waters of New England and each year the MSRP fields anecdotal reports of white sharks, which in most cases are misidentified. Published information on the distribution of the white shark in the western North Atlantic indicates that this species is most abundant in the Mid-Atlantic Bight on the continental shelf between Cape Hatteras, North Carolina and Cape Cod, Massachusetts. Moreover, more young white sharks have been caught in this area than in any area of comparable size in the world. In August 2002, a small great white shark (ca. 109 cm FL) was captured in a trawl net (between the Elizabeth Islands and Martha's Vineyard) and reported to the MSRP. Prior to this, two small white sharks were reported from this region, one harpooned off Boston in 1948 (ca. 81 cm FL) and one netted off Rhode Island in 1939 (ca. 138 cm FL). Length at birth of the white shark is estimated to be 108.0-136.0 cm FL. Therefore, these small white sharks were among the smallest reported free-swimming white sharks and clearly young of the year animals. It is likely that *Carcharodon carcharias* uses the neritic waters of the Mid-Atlantic Bight including the coastal waters of Massachusetts as a secondary nursery area.

Basking Shark, *Cetorhinus maximus*

In the western North Atlantic, the basking shark is known to concentrate in the spring and summer in areas of high productivity and along thermal fronts on the continental shelf from southern New England to Newfoundland. The basking shark is well documented off the coast of Massachusetts and basking shark reports to the MSRP have ranged from the coastal waters of Buzzards Bay, Vineyard Sound, Cape Cod Bay, and Massachusetts Bay to the offshore waters of the Great South Channel and Stellwagen Bank. Very little is known of the size and age structure of the basking shark population in these waters, but it is thought to comprise juveniles and adults.

From 1984 to 2003, seven stranded or incidentally captured basking sharks (three males, four females) were examined by the MSRP. Males ranged from 320-696 cm FL and females ranged from 310-690 cm FL. Two of the males and all four of the females were found to be immature. It is clear that the coastal and offshore waters of southern New England provide important secondary nursery habitat for this planktivorous species. The extent to which this region serves as primary nursery habitat is unknown because neonates and pregnant females remain elusive.

Tiger Shark, *Galeocerda cuvieri*

The tiger shark is generally reported from tropical and warm temperate waters of the western North Atlantic, but it is rarely encountered north of the Mid-Atlantic Bight. There are previous reports of juvenile tiger sharks in coastal waters south of Cape Cod, but from 1987 to 2002, the five tiger sharks recorded by offshore fishing tournaments were caught several miles south of Martha's Vineyard and Nantucket Islands. In June 2001, a juvenile female tiger shark (133 cm FL) was taken by a recreational fisherman off the southern shore of Martha's Vineyard. Although historically present, tiger sharks were rare in recent years as is their utilization of Massachusetts coastal waters for secondary nursery habitat.

Shark Fisheries

With the exception of trawl, gillnet, and longline fisheries that target spiny dogfish, *Squalus acanthias*, there are no directed commercial fisheries for sharks in Massachusetts. Of the 1,740 metric tons (MT) of sharks landed in the Commonwealth in 2002, 99% were spiny dogfish and the remaining 1% (15.8 MT) comprised pelagic sharks including shortfin mako (*Isurus oxyrinchus*), porbeagle (*Lamna nasus*), and blue (*Prionace glauca*) sharks taken incidental to offshore trawl, longline, and gillnet fisheries. However, a substantial recreational fishery for sharks occurs off the coast of Massachusetts from June through September each year. The most recent estimates from the National Marine Fisheries Service (NOAA Fisheries) Marine Recreational Fishery Statistics Survey (MRFSS) indicate that Massachusetts recreational fishers caught about 430,000 sharks in 2002, with spiny dogfish comprising 99% of the catch. The MRFSS estimates that the balance of the catch were blue and shortfin mako sharks as well as the smooth dogfish, *Mustelus canis*, and the sandbar shark, *Carcharhinus plumbeus*. Although Massachusetts recreational fishers target sharks, few are landed; MRFSS estimated that 82% of the 2002 catch was released.

Limitations of Shark Monitoring

There are indications that MRFSS data do not adequately reflect the extent to which sharks utilize the neritic waters of Massachusetts. Specifically, the survey does not fully represent species composition, fails to generate accurate indices of relative abundance, and does little to identify the temporal and spatial distribution of sharks and shark nursery habitat in these waters.

D) Shellfish Resources – Commercial Shellfisheries and Aquaculture

MARINEFISHERIES SHELLFISH SANITATION AND MANAGEMENT PROGRAM

The Shellfish Program has two primary missions, public health protection, and both direct and indirect management of the Commonwealth's molluscan shellfish resources. Public health protection is afforded through the sanitary classification of all 1,745,723 acres of overlying waters within the states territorial sea in accordance with the provisions of the National Shellfish Sanitation Program (NSSP). The NSSP is the federal/state cooperative program recognized by the U.S. Food and Drug Administration (FDA) and the Interstate Shellfish Sanitation Conference (ISSC) for the sanitary control of shellfish produced and sold for human consumption.

Shellfisheries management is accomplished by direct *MarineFisheries* regulation of the commercial surf clam, ocean quahog, and quahog dredge boat fisheries, harvest of contaminated shellfish for depuration and relaying, size and maximum harvest limits of other shellfish, bay scallop and conch seasons, shellfish aquaculture and collection of statistics. Indirectly, *MarineFisheries* manages through its partnership with the coastal cities and towns by providing technical assistance and consultation with local management authorities (elected officials and shellfish constables) in the development of management plans and local regulatory decisions.

COMMERCIAL AND RECREATIONAL SHELLFISH LANDINGS

MarineFisheries is charged with collecting, analyzing, and maintaining an historical database of commercial and recreational shellfish landings. This information is initially collected by each of the 65 coastal cities and towns of the Commonwealth and submitted annually on "Town Landings” forms. Data collected reflects the number and types of permits issued, the pounds of each species landed and by what shellfishing methods. Along with data, the municipalities submit updates of their local shellfishing regulations. These data have been maintained since 1955 in both hard copy and electronic format and is used for fisheries management on the local, state, and federal levels. The following graphics present 2002 coast-wide Massachusetts landings for selected species by statistical reporting areas (Figures 25 – 27).

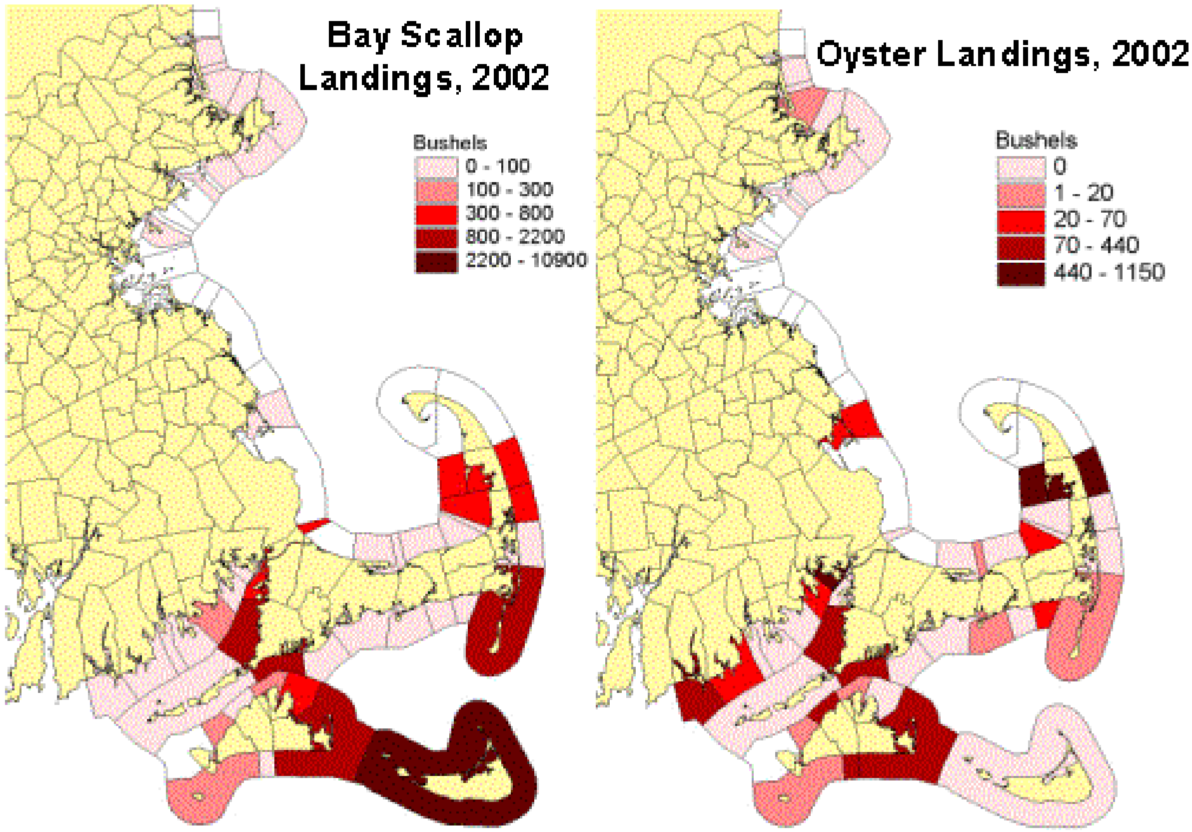


Figure 25. Bay scallop and oyster landings for Massachusetts in 2002.

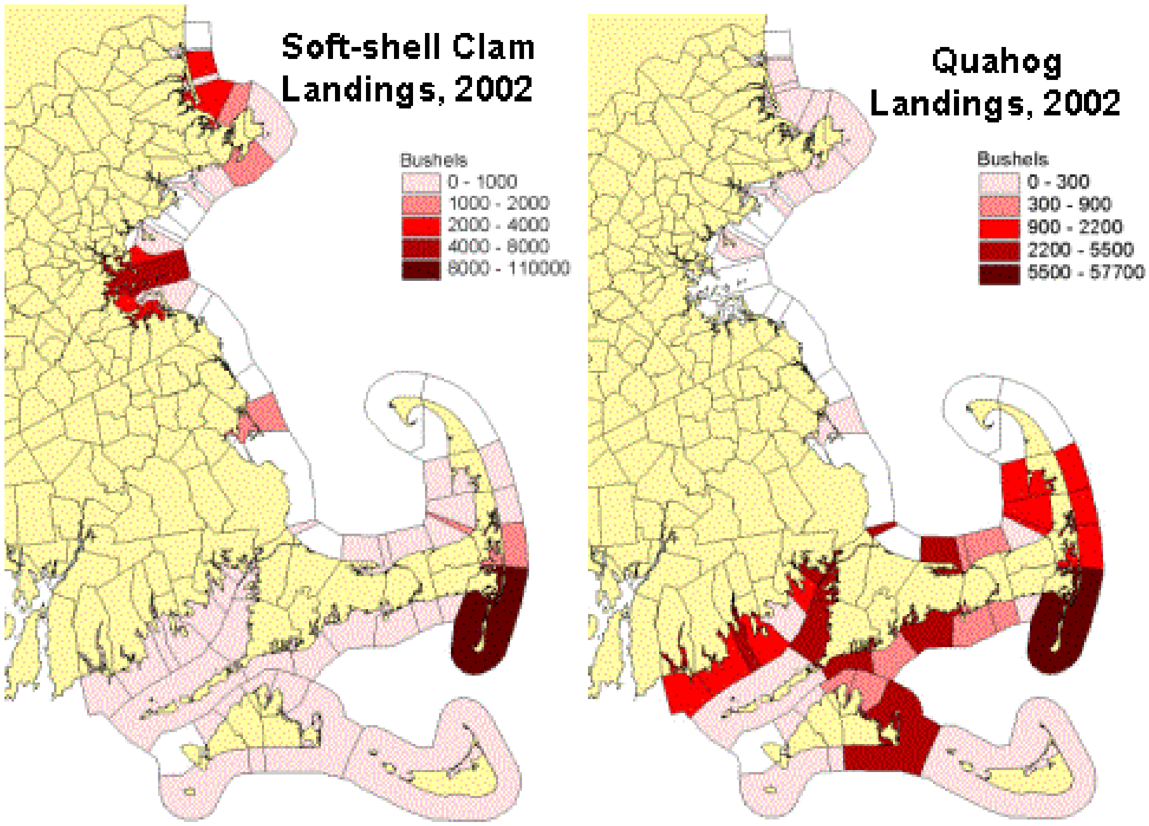


Figure 26. Soft-shell clam and quahog landings for Massachusetts in 2002.

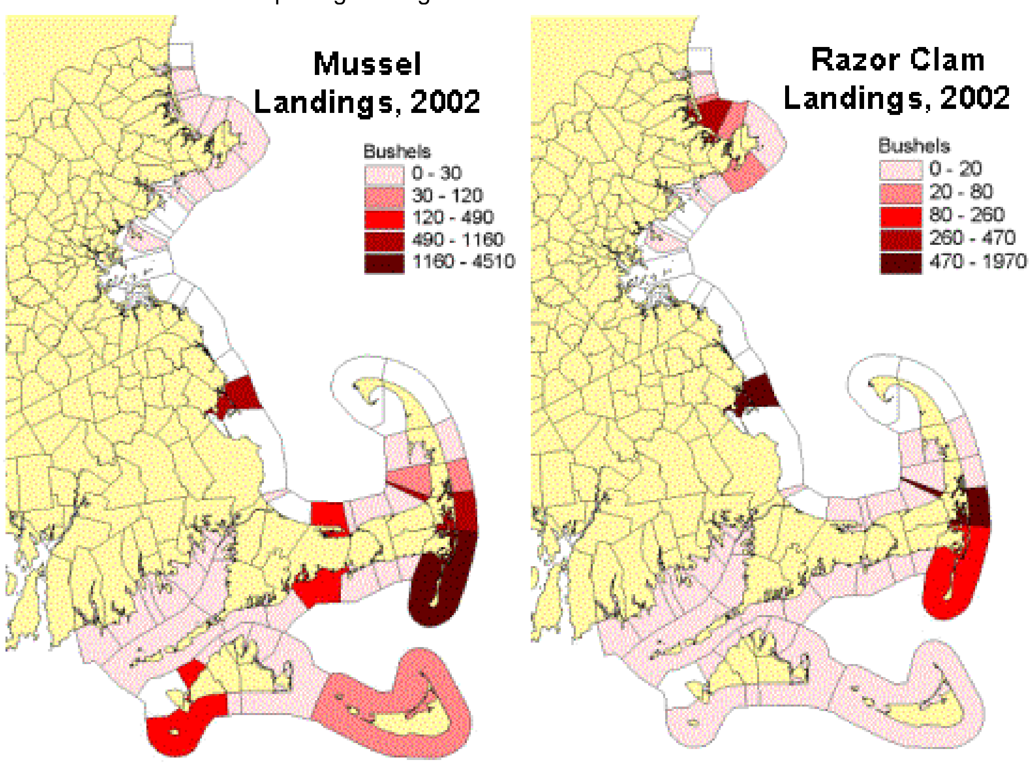


Figure 27. Mussel and razor clam landings for Massachusetts in 2002.

Surf Clam and Quahog Dredge Fisheries - Unlike other shellfisheries in non-contaminated waters that are under municipal control, the commercial harvest of surf clams and ocean quahogs are under *MarineFisheries* control. Likewise, *MarineFisheries* manages the harvest of northern quahogs using dredges in certain waters of the Commonwealth through a limited access licensing process. Currently, there are more than 125 active permit holders that are required to submit monthly catch reports. This catch information is maintained in a multifunctional database that enables fishery managers to determine CPUE, measure the impact of fishing in specific locations, conduct trend analysis, and determine the amount and value of landings. These data, including seasonal catch data (type of fishery and size composition) and landings information, are shared annually with NOAA Fisheries and are incorporated into the total U.S. landings data.

PUBLIC HEALTH

Public health protection is achieved as a result of sanitary surveys of shellfish growing areas to determine their suitability as shellfish sources for human consumption. The principal components of a sanitary survey include: 1) an evaluation of pollution sources that may affect an area, 2) evaluation of hydrographic and meteorological characteristics that may affect distribution of pollutants, and 3) an assessment of water quality.

Each growing area must have a complete sanitary survey every twelve years, a triennial evaluation, and annual review in order to maintain a classification that allows shellfish harvesting. Minimum requirements for sanitary surveys, triennial evaluations, annual reviews, and annual water quality monitoring are established by the ISSC and set forth in the NSSP. Each year water samples are collected at 2,320 stations in 294 growing areas in Massachusetts coastal waters at a minimum frequency of five times while open to harvesting. Water and shellfish samples are tested for fecal coliform bacteria at two *MarineFisheries* laboratories located in Gloucester and Pocasset using a Most Probable Number (MPN) method (American Public Health Association) for classification purposes and a membrane filtration technique (usually M-tec) for pollution source identification.

Shellfish are also tested for various poisonous or deleterious substances based upon an assessment of pollution sources impacting growing areas as determined by the sanitary survey and also as a result of pollution events such as oil and chemical spills. Contaminants periodically recovered from shellfish include hydrocarbons, heavy metals, pesticides, and polychlorinated biphenyls (PCBs). Action and Tolerance levels have been established by the U.S. Food & Drug Administration (FDA) for various contaminants to protect the public.

Biotoxin Monitoring

Besides protecting the public from shellfish borne fecal pathogens, another major aspect of the shellfish program involves monitoring for naturally occurring marine biotoxins produced by the microscopic algae *Alexandrium* spp., also known as "Red Tide", that cause paralytic shellfish poisoning (PSP). Consumption of shellfish containing certain levels of PSP toxin can produce severe illness and even death. Shellfish Program personnel collect shellfish from 15 primary or sentinel stations weekly from April through mid-November. Samples are sent to the *MarineFisheries* laboratory in Gloucester where bioassays determine the levels of toxin in the shellfish. If toxin is found, both the frequency of sampling and the number of sample sites are increased. Shellfish areas are closed if toxin levels exceed safe limits. In addition to bioassays, the Shellfish Program oversees a pilot phytoplankton monitoring program under a grant from the U.S. FDA, Office of Seafood. "Volunteers" (mostly local shellfish department personnel or others with strong biology backgrounds) trained and equipped with field microscopes and plankton nets by *MarineFisheries* and FDA, collect and analyzed hundreds of phytoplankton samples. The purpose of this program is to augment the shellfish analysis by providing early warning of potentially toxic blooms besides *Alexandrium* such as *Dinophysis* and *Psuedonitzchia* and to expand the number of sites being monitored along the coast.

Other Activities

Another component of the sanitation program involves maintaining a direct link with the state Department of Public Health (DPH) on all matters related to shellfish safety and public health protection. *MarineFisheries* provides information regarding harvest area status and assists DPH in tracing the source of shellfish in commerce. The agency also aids DPH in the regulation of shellfish wet storage by wholesale dealers and Shellfish Program personnel certified by FDA as Laboratory Evaluation officers evaluate non-state laboratories that conduct shellfish related analyses.

CONTAMINATED SHELLFISH RESOURCES

Under the relay program, *MarineFisheries* permits municipalities to relocate contaminated shellfish to clean waters for natural purification and propagation. Relays are conducted under stringent NSSP guidelines and are heavily supervised by state and local enforcement authorities. Contaminated shellfish must remain at the relay site for a minimum of three months and also for the duration of one spawning season. Shellfish are tested prior to relaying and again before harvesting for human consumption to insure that they meet NSSP requirements for safety. The northern quahog is most often transplanted at around 14-18,000 bushels a year. Oysters and soft-shelled clams are also moved. Most contaminated quahogs are obtained from the waters of the Taunton River - Mount Hope Bay area, and the waters of New Bedford, Fairhaven, and Dartmouth. This method of shellfish propagation affords participating municipalities a relatively inexpensive source of shellfish for use as spawning stock and also allows eventual utilization of the contaminated resource thus eliminating the temptation of illegal harvesting by removing the stock from contaminated areas.

Depuration

The management and oversight of soft-shell clam depuration is a substantial activity for *MarineFisheries*. Clams are harvested from specially designated, conditionally restricted areas of Boston Harbor and transported by *MarineFisheries* licensed and bonded master diggers under strict enforcement to the Shellfish Purification Plant located on Plum Island in Newburyport. Once at the Shellfish Purification Plant, the clams are treated in a controlled aquatic environment and purified. The Shellfish Purification Plant is a state of the art facility containing nine depuration units. Pure seawater is obtained from two deep salt-water wells and is continuously disinfected using ultra-violet light. Depuration is a complex biological process requiring constant validation, during and upon completion of the treatment, through testing of shellfish and tank water. This is accomplished by daily testing in an on-site certified laboratory. The depuration process occurs for a minimum of three days and upon completion, the clams are returned to the harvesters, who pay a depuration fee. The purified clams are then sold in commerce.

The Newburyport Shellfish Purification Plant, in operation since 1928, is the oldest and largest continually operating depuration facility in the country. It is also the only publicly owned and operated depuration plant in the United States. The plant is open 364 days a year and processes an average of 560 bushels of soft-shelled clams per week.

Contaminated Bait

Currently, the only contaminated shellfishery for bait is the heavily regulated, occasional surf clam dredge boat fishery. Recent activity has been minimal.

Environmental Protection

Shellfish Program personnel respond to pollution events in coastal waters in order to assess possible damage to shellfish resources and to determine the need for public health closures. These events include sewage discharges, boat sinkings, petrochemical spills, and other discharges of hazardous chemicals.

AQUACULTURE MANAGEMENT

A major management and technical assistance endeavor of the Shellfish Program is the regulation of shellfish aquaculture. This activity involves two areas of concern: licensing of sites by municipalities and the permitting of aquaculturists to obtain and possess sub-legal shellfish (seed) for transplant and grow-out to legal size. *MarineFisheries* aids municipalities by certifying after inspection of the project area, (as required by statute Chapter 130, Sec. 57; MGL) that the license and operation will cause no substantial adverse effect on shellfish or other natural resources of the city or town. Aquaculturists are required to obtain an annual *MarineFisheries* propagation permit specific to the needs of the individual grower based upon a permit application. The purpose of this process is to control the introduction of shellfish diseases, non-native shellfish species and other pests or predators into Massachusetts waters. About 300 propagation permits are issued each year. Other related activities include: assisting individuals in the licensing and permitting process, providing information on aquaculture to interested parties, assisting municipalities with site selection prior to formal site survey in order to avoid *MarineFisheries* denial, and assisting growers in finding seed sources, and working with hatcheries to become certified to sell seed in Massachusetts.

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2. MARINE MAMMALS AND TURTLES

The coastal and offshore marine waters of Massachusetts provide habitat for many species of whales, porpoises, dolphins, seals (Table 1) and turtles (Table 2). From the times prior to the colonization of Massachusetts to the present, marine mammals and turtles have always had an important role in the lives of the coastal residents.

Within coastal and offshore waters of Massachusetts, 34 species of marine mammals and turtles are documented (Table 1 and 2). These species include 17 whales, five dolphins, one porpoise, four seals, the walrus, five marine turtles and one coastal turtle (Cardoza and Mirick 1987; Cardoza 1979).

Table 1. List of marine mammals found in Massachusetts waters and population estimates.

COMMON NAME	SCIENTIFIC NAME	OCCURRENCE IN MASSACHUSETTS & POPULATION ESTIMATE
Northern Right Whale	*Eubalaena glacialis*	A U.S. and state-listed endangered species. Formerly stranded frequently. Recently observed in waters of Plymouth, Barnstable, and Nantucket counties. Most of Cape Cod Bay included in designated federal Critical Habitat. Minimum population estimate is 201*.
Minke Whale	*Balaenoptera acutorostrata*	Inshore waters; stranded Barnstable and Essex Counties. Minimum population estimate 3,515*.
Sei Whale	*Balaenoptera borealis*	A U.S. and state-listed endangered species. Stranded in Plymouth and Barnstable counties. No minimum population estimate is available*.
Blue Whale	*Balaenoptera musculus*	A U.S. and state-listed endangered species. Stranded in Essex County. Minimum population estimate 308*.
Fin Whale	*Balaenoptera physalus*	A U.S. and state-listed endangered species. Formerly common offshore. Stranded in Plymouth, Barnstable, and Dukes Counties. Minimum population estimate 2,362*.
Humpback Whale	*Megaptera novaeangliae*	A U.S. and state-listed endangered species. Observed in Plymouth and Essex county waters, stranded Barnstable and Nantucket Counties. Minimum population estimate 647*.
Common or Saddle-backed Dolphin	*Delphinus delphis*	Reported from Barnstable and Dukes Counties. Minimum population estimate 23,655*.
Long-finned Pilot Whale	*Globicephala melaena*	Occurs in schools, frequently stranded. Reported from Essex, Barnstable, Dukes, and Nantucket Counties. Minimum population estimate 11,343*.
Grampus or Risso's Dolphin	*Grampus griseus*	Offshore; observed Dukes County waters. Minimum population estimate 22,916*.
Atlantic White-sided Dolphin	*Lagenorhynchus acutus*	Coastal waters; stranded in Barnstable and Dukes Counties. Minimum population estimate 37,904*.
White-beaked Dolphin	*Lagenorhynchus albirostris*	Coastal waters; reported from Essex and Barnstable Counties. Minimum population estimate is not available*.
Orca or Killer Whale	*Orcinus orcus*	Offshore waters; stranded in Barnstable County. Minimum population estimate is not available*.

Table 1. List of marine mammals found in Massachusetts waters and population estimates (cont'd)

Harbor Porpoise	*Phocoena phocoena*	Coastal waters; reported from Essex, Bristol, and Dukes Counties. Minimum population estimate 74,695[*].
Striped Dolphin	*Stenella coeruleoalba*	Pelagic; reported from Essex, Plymouth, and Barnstable Counties. Minimum population estimate 44,500[*].
North Atlantic Bottle-nosed Dolphin	*Tursiops truncatus*	Inshore waters; stranded in Plymouth County. Minimum population estimate 24,897 for the offshore population not available for the coastal population[*].
Pygmy Sperm Whale	*Kogia breviceps*	Offshore waters; stranded in Essex county and recorded in Bristol County waters. Minimum population estimate 617[*].
Beluga	*Delphinapterus leucas*	Observed in waters of Essex and Barnstable Counties. Minimum population estimate not available[*].
Sperm Whale	*Physeter catodon*	A U.S. and state-listed endangered species. Formerly abundant offshore; stranding in Barnstable, Dukes, Essex, and Nantucket Counties. Minimum population estimate 3,505[*].
Bottle-nosed Whale	*Hyperoodon ampullatus*	Pelagic, stranding in Barnstable County. Minimum population estimate is not available[*].
North Atlantic Beaked Whale	*Mesoplodon bidens*	One record, Nantucket County. Minimum population estimate 2,419[*].
Tropical beaked Whale	*Mesoplodon densirostris*	One record, Essex County. Minimum population estimate 2,419[*].
True's beaked Whale	*Mesoplodon mirus*	Offshore waters; no recorded stranding.
Goose-beaked Whale	*Ziphius cavirostris*	Pelagic, stranding in Barnstable and Dukes Counties.
Walrus	*Odobenus r. rosmarus*	Accidental straggler. Recorded Plymouth County, 1734.
Hooded Seal	*Cystophora cristata*	Accidental straggler. Recorded Essex County. Minimum population estimate is not available[*].
Gray Seal	*Halichoerus grypus*	A state-listed species of Special Concern occurring in Nantucket, and occasionally Dukes, County waters. Also recorded on coast of Essex county, probably as a vagrant from Maine water Minimum population estimate is not available[*].
Harp Seal	*Phoca groenlandica*	Accidental straggler. Recorded Essex County. Minimum population estimate is not available[*].
Harbor Seal	*Phoca vitulina concolor*	Coastal Massachusetts. Minimum population estimate is 91,546[*].

Table 2. Sea turtles found in Massachusetts.

COMMON NAME	*SCIENTIFIC NAME*	OCCURRENCE IN MASSACHUSETTS & POPULATION STATUS
Loggerhead Turtle	*Caretta caretta*	A U.S. and state-listed endangered species. Recorded from coastal southeastern Massachusetts.
Green Turtle	*Chelonia mydas*	A U.S. and state-listed endangered species. Recorded from coastal Barnstable County.
Hawksbill Turtle	*Eretmochelys imbricata*	A U.S. and state-listed endangered species. One confirmed record (NOAA records and Bob Prescott, New England Aquarium).
Atlantic (Kemp's ridley) Turtle	*Lepidochelys kempi*	A U.S. and state-listed endangered species. Recorded from coastal Barnstable County.
Leatherback Turtle	*Dermochelys coriacea*	A U.S. and state-listed endangered species. Recorded from coastal southeastern Massachusetts. Older records from coastal Essex and Suffolk Counties.
Diamondback terrapin	*Malaclemmys terrapin*	A U.S. and state-listed endangered species. Coastal areas of Barnstable, Bristol, and Plymouth counties. Introductions of terrapins from extraliminal sources occurred on at least two occasions.

* Minimum Population estimates from Waring et. al. 2002
All six species of turtle and all six of the large whales species are currently listed on the Federal or States list of threatened and endangered species.

MONITORING

Payne et. al (1990) described current and past monitoring and research of marine mammal and turtle populations in the waters of and adjacent to Massachusetts. All research and monitoring was used as sources for the status, trends, and estimated population size (Tables 1 and 2). Many organizations, such as Manomet Bird Observatory, the Center for Coastal Studies (Provincetown), New England Aquarium (Boston), and Whale Center of New England (Gloucester), monitor and research marine mammals and turtles in Massachusetts and the northwest Atlantic Ocean. Additionally, the use of newspaper clippings (i.e., anecdotal statements) was used to verify sightings or strandings (if this information was not available from a more rigorous literature source).

The University of Rhode Island, New England Aquarium, Center for Coastal Studies, and the Woods Hole Oceanographic Institution, in a Cooperative Agreement with the National Marine Fisheries Service established an "Integrated Program for Research on the Northern Right Whale off the Eastern United States." The program consists of four principal tasks: database management, aerial surveys, shipboard surveys, and photoidentification.

The Marine Mammals Investigation of the NOAA Fisheries does aerial and shipboard line transect surveys in the region from the Gulf of Maine to Florida. The Northeast Fisheries Science Center Sea Sampling Program has collected data on fishing activity and marine mammal interactions since June 1989. Trained observers are used on board randomly selected fishing vessels. The current level of observer coverage is approximately 10 percent of the fishing effort.

Monitoring is also provided by observers that are required as a permit condition, such as dredged material disposal, following a formal review under the provisions of Section 7 of the Endangered Species Act.

POLLUTANT CONTAMINATION

Marine mammals and reptiles occupy several trophic levels of the marine food web and are potential repositories for oceanic contaminants that pass through the food chain. Stranded inshore species provide information on regional trends in contaminant concentration. Offshore species signal the extent to which the seas are being despoiled. Inshore and offshore groups reveal the influence of contaminants and toxins on the health of marine environment. A commitment to collection and long-term storage of marine mammal tissues will enable scientists to monitor occurrence patterns of biological toxins, organochlorines, heavy metals and other contaminants, and this can guide future policy (Geraci and Lounsbury 1993).

In analyzing the data for our waters, the EPA wrote in its Section 7 determination for the Massachusetts Water Resources Authority's Boston Harbor sewage outfall project, "Only trace concentrations of several synthetic organochlorine chemicals were detected in blubber samples collected by biopsy darts from free-ranging right whales in the Bay of Fundy and on Browns/Baccaro Banks off Nova Scotia, Canada." These trace contaminations were polychlorinated biphenyls (PCBs), the pesticide DDT, and its metabolites.

This same EPA report shows that organic and metal pollutants were reported in the tissues of several species of cetaceans from a wide geographic range of habitats. As a general rule, highest concentrations of pollutants are found in toothed cetaceans that feed on large fish and other marine mammals, such as killer whales. Somewhat lower concentrations are found in other toothed cetaceans that feed on a variety of fish and invertebrate prey, particularly in nearshore waters, such as beluga whales (*Delphinapterus leucas*), long-finned pilot whales (*Globicephala melaena*), and harbor porpoises (*Phocoena phocoena*). Among the baleen whales (whales that feed on small shoaling fish and crustaceans, such as humpback whales (*Megaptera novaeangliae*) and fin whales (*Balaenoptera physalis*), higher concentrations of synthetic organochlorines are usually found in blubber and other tissues, compared to whale species that feed primarily or exclusively on herbivorous zooplankton, such as right whales.

Interspecies differences in body burdens of potentially toxic metal and organic contaminants are related to trophic position of the cetacean. Body burdens of many contaminants increase from lower to higher trophic levels in the marine food web. Thus, the right whale, because it feeds at a low trophic level, is less vulnerable to chemical pollution of the marine food web than other cetaceans, such as the humpback and fin whales that feed at a higher trophic level. Although residue levels of some pollutants are very high in some individuals, there is little direct evidence that the residues have impaired reproductive success or cetacean health (USEPA 1993).

SUMMARY

Due to the fact that the marine mammals and reptiles inhabiting Massachusetts coastal waters are geographically wide ranging and the factors that limit their survival are still considerably unknown to science, their protection and management can best be accomplished in cooperation with national and international agencies. The Commonwealth of Massachusetts contributes to the overall effort to protect these rare species and their habitats by sponsoring research, monitoring for their presence, and informing ocean user groups. The most frequent causes of human-induced mortalities to marine mammal and reptile species in our area are ship strikes and entanglements with fishing gear. Methods to reduce these mortalities through new and innovative technologies, and vessel and gear management must be actively pursued.

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3) SEABIRDS, SHOREBIRDS, WATERFOWL AND COLONIAL WATERBIRDS

Birds that are associated with the coast and ocean are divided into four categories: seabirds, shorebirds, waterfowl, and colonial waterbirds.

Seabirds spend most of their lives on the open waters of the ocean, coming to land only to breed. These types of birds are further divided into two groups, coastal or nearshore and oceanic or pelagic. The coastal group is usually found within three miles of land and includes the sea ducks, loons, grebes and gulls. The oceanic group is further off shore and includes shearwaters, petrels, puffins, fulmars, gannets, phalaropes, skuas, kittiwakes, jaegers, and auks.

Shorebirds are migratory and use estuaries and freshwater habitats for breeding, summering, and wintering. They migrate northward in the spring and southward in the fall. Approximately 30 species such as plovers, sandpipers, avocets, and oystercatchers are shorebirds. Shorebirds swarm wetlands, beaches, marshes, and tidal flats looking for food and shelter as they migrate through the region.

Waterfowl spend most of their time in the water and have webbed feet designed for swimming. In Massachusetts there are native species of waterfowl that regularly use the estuaries, rivers, and wetlands for breeding and migratory species that use the coastal areas as a winter habitat or to stop and rest as they migrate. Examples of species that nest and breed in Massachusetts include the mallard, American black duck, and the Canada goose. The brant, greater scaup, and bufflehead are examples of birds that winter here and migrate north for the summer.

Colonial waterbirds and wading birds that nest in colonies along the coast in concentrated areas. There are about 23 species of colonial waterbirds in the Massachusetts coastal area. Examples are cormorants, herons, egrets, ibises, gulls, terns, and skimmers.

POPULATION STATUS OF BIRDS

In Massachusetts among the birds associated with the coast, the Common Loon, Common Tern, Artic Tern, and Least Tern are species of Special Concern under the Natural Heritage Program. The Piping Plover is a Threatened Species and the Pied-Billed Grebe, Leach's Strom-Petrel, American Bittern, Least Bittern and the Roseat Tern are endangered species.

The U.S. Fish and Wildlife Service (USFWS) notes that populations of many species of the wading birds are greatly depressed compared to 100 years ago due to the loss of wetlands. Cormorants on the other hand are over abundant and threaten economic interests such as aquaculture. The cormorant is also a suspect in the decreasing abundance of local sportfish populations. A national management plan for the double crested cormorant was just released. Surveys of colonial waterbirds are conducted on a regular basis but are not standardized. Standardized monitoring techniques are needed, as well as a better understanding of the relationship of the waterbirds to their environment.

The USFWS notes that because many breeding species of shorebirds are dispersed across wide, inaccessible areas, accurate estimation of population sizes is difficult. Some populations are small and warrant special attention, such as the piping plover in Massachusetts. It is believed that many populations of shorebirds are declining, based on counts made during migrations and on the breeding grounds.

Because many waterfowl species are hunted, they are monitored through surveys, harvests, and evaluations of their habitats. The USFWS "Waterfowl Population Status, 2003" notes that the total duck population estimate was 16% higher than the 2002 estimate. The mallard populations were similar but the blue-winged teal, shovelers, and pintail were above last years estimate while gadwall, American wigeon, green-winged teal, redheads, canvasbacks, and scaup were unchanged from their 2002 estimates. In the eastern survey area, total duck population was 17% lower than last year but similar to the 1996-2002 average with the exception of mergansers that decreased 30% from the 2002 estimate. For the northeastern U.S. (New England plus the mid-Atlantic states), overall populations were down 11%. For Canada geese, the Atlantic flyway resident population has increased about 12% since last year's count. The estimates for this population have increased 4% per year since 1994. The greater snow goose population increased 2% per year since 1994; the number counted in the Atlantic Flyway was 7% higher than the previous survey. The 2003 estimate of Atlantic brant in the Atlantic Flyway was 9% fewer than last year's estimate but the estimates overall for the last ten year period have increased 3% per year.

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4) BENTHIC COMMUNITY

The purpose of this section is to summarize the trends observed in benthic community resources based on large-scale (temporal and/or spatial) surveys in Massachusetts coastal waters. The findings reported herein are not comprehensive but are intended to provide an indication of the level of information available for benthic resources.

Benthic community structure reflects the cumulative influences of numerous factors, both natural and anthropogenic, and both acute and chronic. In areas undisturbed by pollutants, physical conditions (including water depth, circulation, exposure, salinity, latitude, and, in particular, substrate) are the primary influences to community structure. The primary characteristics of benthic macroinvertebrate communities are fairly predictable when several of these physical factors are known. Healthy, balanced benthic communities are generally composed of high species richness with a number of species reaching similar abundance levels. The benthic community responds to water quality degradation (e.g., introduction of pollutants, hypoxia/anoxia), sediment quality (deposition of particles of differing grain size, introduction of sediment-bound contaminants), or physical disturbance (e.g., dredging, trawling, storms) by a reduction in species richness and replacement of a diverse community with one dominated by one or a few opportunistic species. The duration or frequency of the perturbation determines whether the benthic community is able to recover to its undisturbed condition. The benthic community can be used, therefore, as a snapshot characterizing the cumulative stresses occurring within a specific system.

Benthic resources range from microscopic sedentary infauna (e.g., polychaetes and small bivalves) and epifauna (e.g., hydroids) to mobile megafauna (e.g., lobsters and crabs) that provide significant functional value to the seafloor. The benthos is the basis for the food web for demersally-feeding fish and invertebrates. A number of benthic species (e.g. mussels) restructure the substrate and create habitat that is useful refuge for other species. Maintenance of a diverse benthic community in the coastal waters of Massachusetts is critical to maintaining the health of demersal fish populations.

Coastal waters of Massachusetts comprise a wide range of substrate conditions, resulting in high benthic habitat diversity. Substrate mapping is available for some areas, but not most. Increased coverage of substrate mapping will enable resource agencies to better comprehend the type and distribution of key resources, including benthic communities, so that they can be better managed.

Long-term benthic datasets for coastal waters of Massachusetts are limited in their spatial scale. MWRA has conducted surveys in Boston Harbor and Massachusetts Bay consistently since 1992. The EPA and Army Corps of Engineers have conducted periodic surveys in New Bedford Harbor in support of the Superfund cleanup efforts since 1993. More recently, additional long-term monitoring efforts have been initiated in Massachusetts Bay and Boston Harbor to document recovery of benthic resources following construction of the HubLine gas pipeline. Other portions of the coastal waters are less well documented, although the recent efforts undertaken, through the Massachusetts Ecosystem Assessment Program (MEAP; as part of EPA's National Coastal Assessment program) have expanded the geographic coverage. MEAP, a five-year program initiated in 2000, has sampled approximately 90 locations in Massachusetts coastal waters, with emphasis on estuarine locations and large, previously understudied coastal areas such as Cape Cod Bay, Nantucket Sound, and Buzzards Bay. This program includes sediment chemistry and fish surveys along with the benthic community analysis. While this program is spatially comprehensive, few locations will be sampled repetitively. As a result, data can be used to identify areas of concern for future studies but can not readily identify trends. Results of benthic community studies are not currently available.

There are many examples of temporally and spatially limited benthic community studies. These studies may not provide evidence of trends in resource abundance and quality, but provide a 'snap-shot' of the condition of benthic resources and can serve as a baseline for subsequent monitoring. For example, the Massachusetts Office of Coastal Zone Management (CZM) assessed the benthos (using sediment profile imagery and benthic grabs) in Gloucester Harbor, Salem Sound, Boston Harbor, New Bedford Harbor, and Fall River Harbor. The CZM data are temporally limited, but contain a decent spatial coverage to characterize benthic resources in these harbors (CZM 2003). The benthic community around Gloucester's historic and new wastewater outfall has been monitored for years, providing a long-term but spatially limited data set to examine the benthos (e.g., Michael and Fleming 2000).

Boston Harbor and Massachusetts Bay

Benthic community is better known for Boston Harbor and Massachusetts Bay than many other parts of the coast because of the major construction projects that have occurred in these waters. Massachusetts Water Resources Authority (MWRA) has performed extensive benthic studies since 1989 in support of the upgrade of their sewage treatment facilities. Elimination of sewage sludge and sewage effluent discharges into Boston Harbor has resulted in dramatic improvements in water quality and benthic community structure. What was once a depauperate benthos comprising primarily small short-lived opportunistic species indicative of a highly enriched environment is now a relatively stable, diverse community with large populations of the amphipod *Ampelisca*, a favored food resource for winter flounder (Kropp, et al. 2002b).

Surveys documenting baseline conditions prior to the operation of MWRA's ocean discharge in 2000 have been conducted since 1992 (Kropp, et al. 2002a). The majority of the stations studied in this program have fine-grained substrates and the characteristic fauna dominated by polychaete worms. In sandy areas, polychaetes and amphipods dominate. These annual surveys have documented the natural variability that occurs in the soft-bottom benthic community. A significant storm in 1992, generating >7m waves, caused a substantial change in the soft-bottom community, including marked reductions in abundance and species richness. Both of these indicators gradually increased through 1999 and then started declining again. No noticeable effects were found after one year of discharge and no values were outside the caution threshold range established in MWRA's National Pollution Discharge Elimination System permit.

Surveys were conducted during two seasons (winter and summer) in various substrates along the HubLine corridor prior to construction to establish baseline conditions. Postconstruction monitoring is planned to take place for several years to confirm reestablishment of the benthic community in each substrate type.

In soft substrates that occurred along the majority of the route, the benthic community was dominated by polychaetes, although most areas were also inhabited by amphipods (TRC and NAI 2003a). The strongest station affinities were related to depth rather than sediment. Only one location in Boston Harbor was characterized by a high population of an opportunistic species. In general, species richness was high, an indication of a healthy community.

The pipeline route crossed a limited amount of hard substrate in several areas. There were distinct spatial differences in community structure (TRC and NAI 2003b). Stations in Salem Sound were characterized by extensive growth of coralline algae and limited amounts of foliose algae and the reverse was true at stations near the mouth of Boston Harbor. Typical fouling species such as hydroids, bryozoans, tunicates, and sponges were common near Boston Harbor and rare in Salem Sound. Echinoderms (sea urchins and sea stars) were more numerous in Salem Sound. As the pipeline route was selected to purposely avoid hard substrate, the findings of this survey may not be representative of this habitat within Massachusetts Bay.

Glacial till substrate is difficult to sample and is generally avoided. Because the Massachusetts Bay seafloor is a mosaic of substrate conditions and glacial till has the potential to support early benthic phase lobsters, it was included in the HubLine monitoring program. Most glacial till stations supported a moderate abundance of benthic organisms (TRC and NAI 2003c). Species richness (number of taxa) in glacial till is high, a reflection of the diverse substrate with a variety of niches. Species ranged from infauna to sessile and motile epifauna.

New Bedford Harbor

Much of New Bedford Harbor, particularly the upper harbor, has been compromised by PCB and metals contamination. EPA developed a long-term monitoring program to document changes in the benthic community as Superfund cleanup operations progress. Baseline sampling was conducted in 1993. The benthic community exhibited a distinct gradient from the upper harbor to the outer harbor that paralleled sediment quality (Nelson, et al. 1996). The upper harbor supported a benthic community that was typical of a stressed environment, with dominance by opportunistic species and low species diversity while the benthic community in the outer harbor had high species richness and more evenly distributed species abundance. Benthos in the lower harbor was intermediate between the upper and outer harbor areas. Additional sampling was conducted in 1996 and 1999. Nelson (U.S. EPA-Narragansett, pers. comm.) indicated that little change in the benthos is evident over this time period, a finding that is consistent with the fact that only a small area of the harbor has been remediated to date.

SUMMARY

The benthic community is not systematically monitored in Massachusetts waters, with the exception of targeted monitoring for American lobster and areas impacted by the MWRA outfall and New Bedford's Superfund cleanup. Subsequently, no long-term datasets exist to document coast-wide trends in the abundance and composition in Massachusetts. The few data that exist provide an indication of trends in the benthic community, yet these monitoring programs are also limited to the relatively recent past (10 years). To fully understand trends in the benthic community, more detailed data is required and a targeted monitoring program needs to be developed and implemented.

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5) MARINE BIOINVASIONS IN MASSACHUSETTS: AN OVERVIEW OF STATUS AND TRENDS

Human mediated marine invasive species introductions have likely been occurring in the northeastern United States since the beginning of European exploration and settlement. Some of our earliest invaders likely arrived as fouling or boring organisms on wooden ships, or as hitchhikers in solid and wet ballast. These early introductions include species such as the European green crab (*Carcinus maenus*) and wood-boring shipworms (three nonindigenous species) that continue to result in significant ecological and economic impacts.

Though ballast water continues to receive the most attention as a transport vector for marine and freshwater invaders, many other trade related mechanisms are also important species importers. The aquarium trade, aquaculture and the seafood industry, recreational boating, and marine research, to name just a few, have all been shown to be potential means of introduction. With the rise of global commerce and faster, more efficient shipping fleets, many researchers surmise that the result will increase introduction rates. Ruiz (2000) estimates that of the 374 marine invasions that occurred in the U.S. since the late 1700s, 150 occurred since 1970.

The marine invasive species picture in Massachusetts and the Gulf of Maine is incomplete. Carlton (2003), lists 85 introduced species and 67 cryptogenic species (species of unknown origin) that became established from Nova Scotia to Long Island Sound. This list was compiled based on literature surveys, personal observations, and some of the monitoring efforts cited below. However information related to the spatial coverage and ecological impacts of most of these species is limited. Marine invasive species monitoring efforts traditionally focused on tracking the population expansion of a few high profile species, or on localized surveys of species presence or absence in association with academic institutions.

The first comprehensive survey of nonindigenous species in Massachusetts occurred in the summer of 2000 when a team of taxonomists led by the Massachusetts Bays National Estuaries Program and MIT Sea Grant conducted a rapid assessment survey of 20 sites along the Massachusetts Coast. The survey focused on the fouling community and documented the presence of 24 nonindigenous and 49 cryptogenic species. Three of these species were new records for Massachusetts (Pederson 2001). This survey was repeated for many of the Massachusetts sites in the summer of 2003. Results are forthcoming.

Managers dealing with the invasive species issue in the northeast recognize the importance of improving monitoring and data management related to marine bioinvaders. The Massachusetts Office of Coastal Zone Management and the Northeast Aquatic Nuisance Species Panel are working to develop a web-enabled database of marine invaders in the region (the Marine Invader Database). The database will compile records from the rapid assessment surveys, localized monitoring efforts, and single species monitoring efforts to generate a more complete picture of historic introductions, as well as range expansion and potential impacts of marine bioinvaders. This database is expected to be web published by the spring of 2004.

Marine bioinvasions continue to be an important and difficult issue for marine resource managers. Threats not only include the potential for the new introduction of a catastrophic invader, but also the continued range expansion of already established species. The recent colonization of George's Bank by the tunicate *Didemnum vexillum* is a prime example.

SUMMARY

The distribution of marine invasive species is poorly understood. Data management and management of the transport of these species will be an essential component of any effort to document trends in marine bioinvasions in Massachusetts. More information on the location of introductions, rate of population growth and spread, and species distributions is essential for developing prevention, control, and mitigation strategies for marine invaders. While ballast water is the best known transport vector for marine invaders, many other vectors (e.g., seafood industry, pet trade, and aquaculture) also transport invasive species. Engaging these industries through education and outreach will be essential for effective management of marine invaders. More information on priority transport vectors and marine invaders can be found in the Massachusetts Aquatic Invasive Species Management Plan, available at http://www.state.ma.us/czm/invasivemanagementplan.htm.

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ESTUARINE AND MARINE HABITAT

Massachusetts is located at the intersection of two biogeographic regions, the Virginian and Acadian provinces. Biogeographic regions are identified by distinct differences in biological communities, physical characteristics, and weather patterns. Cape Cod forms the boundary between the two provinces. The Acadian province is north of Cape Cod and encompasses the Gulf of Maine ecosystem. Waters south of Cape Cod are in the Virginian province, including Buzzards Bay, and are representative of northern Mid-Atlantic Bight waters. These two regions support a diversity of physical features and biological communities. Although differences exist, there are also overlapping characteristics between the Virginian and Acadian provinces in Massachusetts. The biogeography north and south of Cape Cod make Massachusetts a region of relatively high biological and habitat diversity. The diversity in environmental resources of Massachusetts is obvious by the marked variability observable along the Massachusetts coast, such as the distinct variation in the rocky shoreline of Cape Ann and sandy beaches of Cape Cod.

Habitat is a term that evokes debate and is often difficult to describe because there are different perspectives on its definition. Habitat is generally thought of as a place where an organism is found, such as estuaries, salt marsh, seagrass, and cobble fields (Odum 1971). Describing habitat is complicated by issues of scale and complexities in natural resources. Right whale habitat is described in terms of oceans (1000s km), while juvenile fish habitat is described by unique seafloor characteristics or microhabitats (cm to m). In spite of how habitat is described and issues of scale, the ocean environment in Massachusetts contains a diversity of environmental resources that support a diversity of organisms and life history stages.

Human-induced perturbations and natural processes influence the abundance, quality and functions of habitats and environmental conditions in Massachusetts. Large storms and ice scour, for example, can substantially change the quality of nearshore seafloor habitats. However, these naturally occurring processes do not affect estuarine and marine habitat to the extent of human activities. Human activities have dramatically altered the extent and quality of estuarine and marine habitats throughout the state. Pollution, eutrophication, coastal alteration and fishing practices have wide ranging impacts to habitat. Depending on habitat type, geographic location, and type and extent of human impact, the ecological consequences of anthropogenic degradation can greatly vary. While the variety of human-induced impacts are not thoroughly documented through time, the effects of many types of impacts are understood and warrant mention in this report.

This section of the Technical Report summarizes data for select estuarine and marine habitats. Habitat features are described for nearshore and offshore systems. Given the inherent relationship between living marine resources (Technical Report #5) and habitats (Technical Report #6), there is overlap in the description of particular resources (e.g., American lobster and habitat associations). This report does not attempt to describe habitat for specific animals, but provides an overview of recognized systems (i.e., salt marsh, tidal flats and seagrass), environmental features that influence habitats, such as seafloor geology, water depth and topography, relatively unevaluated habitat types, and a general summary of human-induced threats and natural processes that affect habitat.

Where available, data on specific habitat conditions and species (e.g., salt marsh and eelgrass habitats) are described in detail; however, the distribution and abundance of many habitats and environmental features are unknown in Massachusetts. The functions of particular habitat characteristics, such as the sedimentary environment of the ocean floor, are summarized, but this section is not a comprehensive review of all species, communities, or ecological services associated with the habitat.

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1. ESTUARINE AND MARINE WETLAND HABITAT

Before describing wetland habitats, a word about what we mean when we use the term, "Wetland." It is a term that includes a wide variety of marshes, swamps and bogs, and coastal resources and landforms (e.g., beach, rocky intertidal and submerged habitats). Wetland habitats are found throughout terrestrial and coastal areas in Massachusetts. The Massachusetts Wetlands Protection Act identifies "Land Under the Ocean," "Coastal Beaches and Dunes," "Barrier Beaches," "Coastal Dunes," "Rocky Intertidal Shores," "Salt Marshes," "Land Under Salt Ponds," "Land Containing Shellfish," and Fish Runs" as coastal wetland resources and regulates activities in these habitats. Wetland resources are also classified in terms of their ecological characteristics. The ecological classification of wetlands is based on hydrology, vegetation, and substrate and are grouped into five distinct systems (palustrine, lacustrine, riverine, estuarine, and marine; see Cowardin et al. 1979). Wetland habitats, regardless of the classification and regulation, are important coastal resources and provide a number of ecologic and economic roles and services.

This section describes tidal wetlands, including estuarine and marine salt marsh and tidal flat habitat. The omission of other coastal wetland resources (e.g., coastal banks, salt ponds, beaches and dunes) that are critically important in Massachusetts does not discount their importance.

Vegetation and animal communities of salt marsh and tidal flat systems are variable in Massachusetts on regional and local scales (see Nixon 1982 and Teal 1986). Vegetation communities in salt marshes are more stable and predictable compared to animal communities. *Spartina alterniflora* and *S. patens* generally dominate vegetation communities, with several other plant species (e.g., *Salicornia sp., Distichlis spicata, and Juncus gerardii*) contributing to overall salt marsh vegetation community diversity. Tidal flats appear at lower tides as unvegetated areas of mud and sand. The mud and sand contain abundant microscopic plants, such as diatoms, algae and dinoflagellates, and a diverse invertebrate community. The invertebrate community can contain valuable commercial and recreational shellfish (e.g., soft-shell clams). Regions with large tidal regimes have more area of tidal flat habitat. For example, there are larger areas of tidal flat in Massachusetts Bay compared to southern New England.

Ecological and economic functions of marine and estuarine wetlands are diverse and include fish, invertebrate, insect and wildlife habitat; primary production and organic matter exportation; water quality maintenance; flood protection; and shoreline erosion protection. The aesthetics of open space, nature recreational activities (e.g., shellfishing, wildlife observation and photography), commercial shellfishing, education opportunities, and agriculture (e.g., haying) are highly valuable socio-economic attributes of coastal wetlands (Tiner 1984).

The perception of wetland value has dramatically changed through time. Wetlands were once considered wastelands, but scientific studies demonstrated the importance of wetland resources and increased public awareness of wetland functions (Tiner 1984). The increase in public awareness led to laws specifically designed for wetlands protection, and Massachusetts passed the Wetlands Protection Act in 1963. The federal government followed by adding wetland protection provisions to the Clean Water Act (1970s) and Section 10 of the River and Harbor Act of 1899. These laws and the increased understanding and appreciation of resource values slowed the destruction of wetlands.

Wetland resources, including salt marsh and tidal flat habitat, are mapped by the Massachusetts DEP Wetland Conservancy Program with support from the University of Massachusetts at Amherst (MassGIS 2003). Coastal habitats were mapped in the 1990s and the focus is on completing the entire state before updating existing maps. The National Wetland Inventory (NWI) of the US Fish and Wildlife Service (USFWS) also maps wetlands and has completed the entire state, though the date, scale, and accuracy of the NWI maps vary. Despite this strong body of information on the location and type of wetland resources (i.e., wetland quantity), there is limited information documenting historical wetland losses and only scarce data are available regarding the status of wetland condition or quality (B. Carlisle personal communication). This section summarizes major influences to wetland distribution and quality, describe national trends (noting Massachusetts-specific information, where available and appropriate), and describe the current distribution of salt marsh and tidal flat habitat in Massachusetts.

ANTHROPOGENIC AND NATURAL INFLUENCES OF ESTUARINE AND MARINE WETLANDS

Prior to the passage of the Massachusetts Wetlands Protection Act (1963), countless acres of salt marsh and tidal flat habitat were filled, drained and dredged to support the development and growth of urban and residential areas and agricultural lands. Substantial wetland filling occurred for over three centuries in Massachusetts (1600s-1900s). New direct filling and draining are currently not large problems, although loss of wetlands remains a problem. Indirect alteration to wetland quality through changes in tidal hydrology, watershed development, and pollution continues to degrade large areas of coastal wetlands. Natural processes, such as sea level rise, subsidence and severe weather (droughts and ice scour) also influence wetland distribution and quality.

The rate of sea level rise, tidal regime, sediment supply, and the ability of plants to adapt to salinity change affect the persistence of existing wetlands and development of new wetlands. Sea level rise and subsidence are natural processes. Vertical accretion of sediments and horizontal migration of the wetland must offset sea level rise and wetland submergence (subsidence) to maintain wetland resources. If sea level rise and/or submergence rates are greater than accretion and/or migration rates, wetland resources will change into open water habitat (see Teal 1986 for summary). Tidal wetlands, since the glacial period, migrated inland along estuaries, river valleys and coastal slopes or were replaced by open water (Harris MS). The natural migration and evolution of wetland resources is complicated by human development of coastal lands. Estuarine and marine wetlands that are surrounded by development do not have the ability to migrate upland, thereby prohibiting the natural evolution of landscapes. Furthermore, sediment supply, sedimentation rates, and water flow are frequently altered in these areas compounding effects to wetland succession.

Watershed and coastal development substantially influence the distribution and quality of wetland resources. The alteration of land use in watersheds and development adjacent to wetlands can change the rate, volume, drainage patterns, and composition of runoff. These changes can increase pollutant loads (e.g., nutrients and contaminants) and alter water flow (i.e., surface runoff and groundwater) that enter wetland areas, diminishing ecological function (Wigand et al. 2003). Development also has direct impacts on wetlands. For example, dock and pier development directly impacts marsh habitat and is also related to indirect impacts associated with recreational boating (e.g., increased turbidity, pollutant discharge, and prop scarring) that contribute to the degradation of marsh systems.

Salt marshes are commonly crossed by highways, roads and railroads of various dimensions. These features bisect tidal marshes, fragmenting systems into smaller parts and reducing the natural tidal flushing of the marsh. Culverts are frequently placed under roadways to allow tidal passage, and many of these culverts are not properly sized and create tide restrictions. The influence of tides is the major environmental factor affecting salt marsh ecology, and tidal height variations play an important role in the zonation of marsh plant communities. Tide restrictions do not allow for the normal exchange (inundation and draining) of water, causing degradation of the landward (restricted) salt marsh.

Agencies, like the Massachusetts Office of CZM's Wetland Restoration Program, are working with local partners and the private sector to identify and restore marshes degraded by tide restrictions (e.g., Costa et al. 2002). There are also pilot efforts to quantify the relationship between watershed development and salt marsh condition (e.g., Carlisle et al. 2003).

STATUS OF ESTUARINE AND MARINE WETLAND HABITAT

The greatest loss of wetlands occurred between the 1950s and 1970s in the United States. Following World War II, the United States was characterized by rapid urbanization and coastal development, resulting in half of the coastal wetlands being destroyed in the lower 48 states (Tiner 1984). Wetlands were drained, filled and converted to other terrestrial lands (Dahl 1990). Estuarine wetlands are still areas of concentrated development, especially for developers of residential and resort housing and marinas.

Urbanization – residential and commercial development – was attributed to over 90% of the loss to coastal wetlands. Urbanization also accelerated pollution to coastal wetlands, diminishing wetland quality and function. Rising coastal population and economic growth created a high demand and market, which continues today, for coastal real estate; therefore, wetlands near urban centers traditionally concentrated development and remain under constant development pressures and pollutant insults.

Since the 1970s, the rate of wetland loss has substantially decreased due to strict regulations and increased awareness of wetland values. The USFWS studied the national status and trends of wetlands from 1986 to 1997 (Dahl 2000). The study estimated that 5.3 million acres of estuarine and marine wetlands existed in 1997, representing a 10,400-acre loss from 1986. The primary cause of wetland loss between 1986 and 1997 was development and open water intrusion (conversion of vegetated wetland to open water). These national trends serve as a proxy for the status of marine and estuarine wetlands in Massachusetts.

State-Wide

Massachusetts contains more salt marsh than any state in New England, and is second to Maine in tidal habitat area. As compared to Massachusetts, Maine has more tidal flat habitat due to its large tidal range and longer coastline.

Salt marsh and tidal flat habitat maps, available through MassGIS (2003), were created by interpreting aerial photography (1:5,000 and 1:12,000 scale) from the 1990s and field verifying aerial signatures (MassGIS 2003). The salt marsh and tidal flat habitat is stored as geographic information system (GIS) data. The wetland habitat maps and GIS data are for planning purposes only, but provide the best available statewide coverage of wetland resources.

The GIS data show that Massachusetts contains at least 45,435 acres of salt marsh (this is an underestimate, due to the "clipping" of the data to align with the state GIS indexing scheme (see MassGIS 2003 for details; Carlisle personal communication)). Tidal flat habitat in Massachusetts was calculated from an analysis of pre-1990 data and covers 469,600 acres (Field 1991). The same study identified 47,200 acres of salt marsh coverage (Field 1991). The current maps do not indicate the historic distribution and abundance of salt marsh and tidal flat habitat or the current or historic quality of salt marsh and tidal flat habitat.

There is no thorough assessment of changes in wetland resources through time for Massachusetts, though several studies demonstrate marsh-specific changes for specific time periods. The lack of a comprehensive database limits the analyses of trends in wetland distribution and quality. National trends are useful to evaluate changes, but specific details of Massachusetts wetlands would be extremely helpful to document and understand changes in wetland habitats and quality.

Regional Assessment

Discrete areas of coastal wetlands are relatively small in Massachusetts, compared to extensive marshes in the mid-Atlantic and southeast United States. Marshes have suffered from considerable filling, such as the historic marshes of Boston that were filled to create the city (e.g., Back Bay and Logan Airport were originally salt marshes). The variation in geology and tidal regime influences the distribution and abundance of wetland habitat in Massachusetts. Coastal areas of Massachusetts Bay generally support relatively small marshes; although, the largest marsh complex of New England is found northwest of Cape Ann from western Gloucester to the New Hampshire border. Many areas of Cape Cod (Cape Cod Bay, outer Cape, and southern Cape), Nantucket, Martha's Vineyard, and the Buzzards Bay coastline are lined with salt marsh habitat. Examples of salt marsh habitat that represent large and relatively undisturbed salt marsh systems are the Great Marsh complex (Salisbury, Newbury, Rowley, Ipswich, Essex and Gloucester), Nauset Marsh (Eastham and Orleans), and Sandy Neck (Barnstable). Tidal flat habitat is found throughout Massachusetts, with extensive tidal flats found in estuarine systems and along eastern Cape Cod Bay (Wellfleet to Yarmouth).

The following selections summarize regional trends based on existing studies that documented temporal changes in particular marshes. From 1977 to 1985/86, the area from Plum Island to Scituate lost 17.80 acres of estuarine wetlands to commercial business development, highway construction, ditching, and residential housing development (Foulis and Tiner 1994). The Neponset watershed contained 311.64 acres of estuarine wetlands and exhibited no change between 1977 and 1991 (Tiner et al. 1998). A gross spatial analysis, based on Costa (1988) and MassGIS (2003), demonstrated no appreciable loss of salt marsh coverage in Buzzards Bay from the 1980s to 1990s. The limited studies that are available for Massachusetts show little loss of salt marsh habitat in the past several decades.

Trends in tidal flat habitat are largely unknown, and no studies were found that describe changes in Massachusetts. The distribution of tidal flat habitat mapped by DEP provides fundamental data on current tidal flat distribution, but examination of historic losses of tidal flat habitat would be useful to understand changes in the extent and quality of this valuable nearshore habitat.

CZM and USFWS are currently examining long-term changes (early 1900s to late 1990s) in salt marsh habitat to provide a thorough assessment of status and trends in salt marsh distribution on Cape Cod, Nantucket, Martha's Vineyard and greater Boston Harbor (Carlisle personal communication). The CZM-USFWS project will provide fundamental information on changes in salt marsh habitat.

SUMMARY

Estuarine and marine wetlands are highly productive areas found between terrestrial and ocean environments and provide a diversity of ecological and economic values. The distribution and quality of wetlands have not been well documented through time. The information that is available, such as national and watershed-specific studies, shows a tremendous decline in marsh distribution during the 1950s and 1970s. Rates of wetland loss decreased because of new regulations in the 1960s and 1970s. Watershed and coastal development continue to adversely influence wetland integrity and function.

Estuarine and marine wetlands are critical resources to the environmental integrity and economic sustainability of Massachusetts and require thorough monitoring to inform management decisions to protect and restore wetland habitats. A comprehensive monitoring approach would improve the understanding of anthropogenic and natural effects to wetlands and management of these important coastal habitats.

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2. SEAGRASS HABITAT

Seagrass, also referred to as submerged aquatic vegetation, are rooted, flowering plants that inhabit nearshore marine and estuarine systems throughout Massachusetts. Widgeon grass (*Ruppia maritima*) and eelgrass (*Zostera marina*) are seagrass species that inhabit Massachusetts coastal waters. Since eelgrass is more abundant and widespread than widgeon grass in Massachusetts coastal waters, the focus of this report is eelgrass.

All life cycles of eelgrass occur underwater (flowering, pollination and seed germination) and are common to coastal, temperate waters in the northern hemisphere (Pacific and Atlantic Oceans). Eelgrass grows in brackish to marine waters, tolerates a wide range of temperatures and is found from the intertidal zone to approximately 10 m below mean low water (eelgrass was found deeper than 40 feet in Cape Cod Bay and Salem Sound). The depth of eelgrass growth is primarily mediated by the water column light environment (i.e., clearer water supports deeper growth). A range of sediment types, current and tidal regimes and shorelines support eelgrass growth, but eelgrass is predominantly found in calm, nearshore waters with soft sediments (e.g., mud and sand).

The cover of eelgrass on the seafloor is variable, ranging from extensive meadows to patchy submerged clusters and thin, low-density beds. Regardless of eelgrass density, eelgrass is a prolific primary producer, supports diverse animal communities, stabilizes sediments, and filters the water column. Eelgrass produces substantial volumes of organic matter that is fundamental to detritus-based food webs, and marine species (e.g., water fowl, crabs and fishes) directly feed on eelgrass. Eelgrass provides critical habitat for fishes, crabs, clams, and other invertebrates. Bay scallops and American lobster, for example, are two economically important species that inhabit eelgrass habitat. Species less known, such as pipefish, sea horses, and gobies (fish species), sea worms, snails, crabs, and algaes, require eelgrass for survivorship and growth. In addition to its value as food and habitat, eelgrass stabilizes seafloor sediments. The physical characteristics of beaches adjacent to eelgrass bed can substantially change, and shorelines erode when eelgrass beds reduce in size and cover or disappear.

The Massachusetts Department of Environmental Protection (DEP) mapped the distribution of seagrass from 1993 to 1996 (MassGIS 2003). The primary objective of the mapping project was to identify the distribution of eelgrass. Widgeon grass was also found in the study area, but the coverage of the mapping project did not include all potential widgeon grass habitat. The DEP project provided the first statewide assessment of eelgrass abundance. Prior to the statewide mapping, there was little rigorous documentation of the extent and quality of seagrass habitat; therefore, quantitative documentation of trends in seagrass abundance is limited. Mapping by DEP continues on a three to five year cycle, and an updated map will be completed to assess the distribution of eelgrass and evaluate changes in distribution from the first map (updated map is scheduled for completion in spring 2004; C. Costello personal communication). The mapping project is providing the foundation for future analyses of spatial and temporal trends. This section summarizes human and natural influences to seagrass habitat, describes the status of eelgrass habitat, and qualitatively assesses temporal changes in eelgrass distribution.

ANTHROPOGENIC AND NATURAL INFLUENCES OF EELGRASS HABITAT

Eelgrass abundance and distribution fluctuates through time and space due to natural variability. Disease, storms and ice scour, natural sedimentation, and bioturbation influence the quality and extent of eelgrass populations. Wasting disease (caused by slime mold, *Labyrinthula*) is naturally occurring and has had large-scale effects on eelgrass populations. Climate change and sea level rise could also have substantial effects on eelgrass habitat by changing salinity, temperature and tidal regimes and inundating existing suitable habitat. In most cases, eelgrass beds recover from natural events (Costa 1988).

Human-induced impacts to eelgrass populations are evident throughout the state. Physical and chemical insults degrade, reduce and remove eelgrass habitat. Physical impacts, such as scarring from boat propellers, anchors and mooring chains, dredging, and destructive fishing, degrade eelgrass populations. Mooring fields, navigation channels, and aquaculture (e.g., shellfish seeding) are found in areas of historic and existing eelgrass habitat (i.e., shallow waters). The presence of these disturbances in protected bays effectively eliminates eelgrass habitat. Coastal structures (e.g., dock and piers and armored shorelines) reduce available habitat and frequently change natural conditions (e.g., current and sedimentation patterns), leading to loss of eelgrass habitat. In addition to the physical impacts and habitat alterations identified, human activities are often associated with increased turbidity that decreases the light available to eelgrass. Minor changes in light availability can substantially influence eelgrass quality.

Poor water quality and decreased clarity result in the largest scale loss of eelgrass habitat. Water clarity is synonymous with light availability, and light available to eelgrass is dictated by phytoplankton abundance, algae abundance and cover, and sediment suspension (turbidity). Eutrophication (i.e., nutrient over enrichment) increases growth of algal epiphytes (algae species that grow on eelgrass) and phytoplankton that absorb light in water column and prohibit light from reaching eelgrass. Eutrophication decreases water clarity and degrades eelgrass habitat. Low water clarity and high nutrient levels promote the proliferation of benthic and drift algae because these types of algae often have lower light requirements than eelgrass, smothering eelgrass and out-competing eelgrass for space. Other pollutants that influence eelgrass habitat enter coastal waters and degrade and kill eelgrass, such as herbicides used for lawn care by homeowners and larger landscapes (e.g., golf courses).

STATUS OF EELGRASS HABITAT

Few studies systematically document temporal changes in eelgrass habitat. And – documentation that does exist is often qualitative, hindering the understanding of natural fluctuation and human impacts on eelgrass. Studies that demonstrate change in eelgrass abundance and document causes for changes in eelgrass habitat are plentiful outside of Massachusetts (see Fonseca et al. 1998), and these studies can serve as a useful guide to understand natural and human-induced impacts to seagrass and long-term trends in eelgrass abundance. In Massachusetts, Colarusso (personal communication) and Costa (1988) provide the most thorough assessment of historical changes in eelgrass abundance.

Colarusso (personal communication) summarizes gross statewide trends of eelgrass populations, excluding Buzzards Bay. Historic trends in eelgrass abundance of Buzzards Bay were studied by Costa (1988). Comprehensive information on eelgrass quality, such as shoot density, coverage, and growth, are scarce, but there are studies (e.g., Dexter 1985; Short and Burdick 1996) that provide detailed examination of particular harbors that can be viewed as a proxy for regional trends (see cited references and suggested readings for more detail).

State-Wide

Massachusetts DEP mapped the statewide coverage of seagrass to provide a conservative estimate of eelgrass distribution. The maps were created by interpreting aerial photography (collected 1993-1996) and field verifying seagrass photographic signatures (MassGIS 2003). Approximately 39,200 acres of eelgrass and 4.5 acres of widgeon grass were mapped in Massachusetts (MassGIS 2003; Colarusso personal communication). These maps are frequently used as a baseline, but the current maps do not incorporate recent changes in eelgrass or indicate the historic extent or quality of eelgrass habitat.

The capability of mapping large areas of eelgrass is a relatively new development; therefore, quantitative change analyses are only available for the recent past and future. Temporal changes in eelgrass abundance were, however, observed on regional and local scales. These changes were documented in directed studies or have been noted by anecdotal information and personal observations.

Wasting disease decimated eelgrass populations throughout the state, along with the entire North Atlantic Ocean, from 1930 to 1933. Site-specific information on the recovery of eelgrass from the 1930s is rare, but eelgrass abundance generally recovered in 30 years for most areas. However, there is evidence that eelgrass populations in certain areas never recovered from the wasting disease (summarized by Costa 1988). The greatest recovery from wasting disease occurred in the 1950s-1960s. Eelgrass abundance fluctuated prior to the 1930s, but because assessments before 1930 are rare it is difficult to assess changes before this time. The outbreak raised awareness of eelgrass value to coastal environments.

Massachusetts Bays

The Merrimac River, Plum Island Sound, Ipswich, Essex Bay and Newburyport Harbor were devoid of eelgrass in 1995 (MassGIS 2003). This lack of eelgrass indicates a substantial loss since the 1940s. Dexter (1985) documented fluctuation in eelgrass abundance and distribution of Cape Ann from 1933 to 1984. The Cape Ann study, supplemented by recent observations, demonstrated that eelgrass generally recovered from the wasting disease outbreak but disappeared in the Annisquam River by the mid-1980s and early 1990s. Eelgrass persists on the northwest shore of Cape Ann, which is well flushed, compared to the estuarine waters of Annisquam River. The Cape Ann study may serve as a proxy of trends in eelgrass abundance of northern Massachusetts Bay.

Salem Sound supports a consistent and relatively continuous eelgrass meadow from the mouth of the Danvers River in Beverly to Manchester Harbor. These meadows persisted through periods of depressed water quality and currently grow in the deepest water of the state, an indication of good water quality (Colarusso personal communication). Eelgrass was recorded in Salem and Marblehead Harbor (MassGIS 2003), but recent observations (2002-2003) show eelgrass at diminished levels or absent (personal observation). The construction of an underwater gas pipeline (i.e., Hubline) also removed areas of eelgrass and affected eelgrass habitat by increasing turbidity during construction.

Eelgrass mapped in the Swampscott, Nahant and Lynn Harbor is relatively stable; although, a dredging project in Swampscott during the 1990s removed a substantial area of eelgrass. The disturbed eelgrass appeared to recover by 2003 (Colarusso personal communication), probably because Swampscott has well-flushed waters that provide a suitable water column light environment for recovery.

Boston Harbor historically supported large areas of eelgrass, but eelgrass habitat has greatly diminished since the 1800s and early 1900s. Eelgrass was noted as abundant in 1909, sparse in the 1940s, and currently (based on 1995 map) exists in only a few locations (i.e., near Logan International Airport, Bumpkin Island and World's End (Hingham) and Allerton Harbor (Hull); MassGIS 2003).

Several protected areas contain eelgrass in southern Massachusetts Bay. The eelgrass population is relatively consistent in Scituate Harbor, although a recent dredging project removed eelgrass habitat. Cohasset Harbor supported eelgrass in the inner and outer portions of the embayment in the early 1990s, but recent observations (2003) noted the loss of eelgrass in the inner harbor. A large, continuous bed exists in Duxbury and Plymouth and has been persistent for many years.

<u>Cape Cod Bay and Outer Cape Cod</u>

Cape Cod Bay supports a number of small and large expanses of eelgrass habitat. Eelgrass beds are found along the Cape Cod Canal and coastal waters of Sandwich, Yarmouth and Dennis. Eelgrass was documented along Sandwich in 2003. The 1995 map does not show eelgrass in Sandwich waters, indicating a possible expansion of eelgrass distribution. Eastern Cape Cod Bay has the largest contiguous meadow in the state, with extensive coverage of eelgrass found from Provincetown Harbor to Brewster, including a large area of eelgrass habitat on Billingsgate Shoal (Wellfleet). The abundant eelgrass in eastern Cape Cod Bay was not noted in a 1940s study, so the current distribution may demonstrate an increase in abundance. However, eelgrass was noted for Hatches Harbor (Provincetown) but was not mapped in 1995 (MassGIS 2003), representing a possible loss of eelgrass habitat. Historic and contemporary presence of eelgrass shown on maps for Cape Cod may be a factor of sampling methodology and description of eelgrass habitat, with particular techniques more or less efficient at identifying eelgrass.

Nauset marsh (Eastham and Orleans) contained eelgrass habitat mixed with red and green algae in 1985-1986, during a study of fish and invertebrate assemblages (Heck et al. 1989; Heck et al. 1995). Eelgrass was not found in Nauset Marsh in 1995 (MassGIS 2003). The mix of algae within the eelgrass habitat in 1985-1986 may have been a natural occurrence or a sign of excess nutrients. Regardless of the cause of loss, the fact that eelgrass was not mapped in 1995 indicates a loss of habitat. Pleasant Bay and the Monomoy Islands support stable eelgrass meadows, as documented by studies in 1900s, 1940s, 1980s, and recent mapping (1995).

Southern Cape Cod and the Islands

Eelgrass is widely distributed along the southern Cape Cod shoreline. Eelgrass abundance was greater prior to the wasting disease outbreak in the1930s, but recovered and seems relatively stable in well-flushed waters (e.g., open coast). Substantial coverage and volume of macroalgae, such as *Codium fragile* and *Ulva* spp., mix with eelgrass habitat in southern Cape waters. The proliferation of algae species is a relatively recent phenomena. Eelgrass habitat has fared quite differently in the enclosed embayments of southern Cape Cod, with dramatic losses noted in several shallow inlets and embayments.

The loss of eelgrass habitat and cause of eelgrass habitat degradation is thoroughly documented in Waquoit Bay (summarized from Costa 1988; Short and Burdick 1996). Eelgrass recolonized Waquoit Bay after the 1930s. Eelgrass grew abundantly nearshore (especially along the eastern shoreline) and was found in the deepest parts of the bay in the 1950s and 1960s. After 1965, eelgrass began to disappear in deeper portions of the bay. By the mid-1970s, the bay shoreline did not support eelgrass. The loss of eelgrass was attributed to decreased light availability because of increased epiphyte (plant growth on the eelgrass blades) and phytoplankton growth and proliferation of dense drift algae (Costa 1988). Short and Burdick (1996) further studied changes in eelgrass habitat and documented similar trends of diminished distribution and documented dramatic declines in eelgrass abundance. The loss of eelgrass was attributed to increased nitrogen loading associated with increased watershed development in the Waquoit Bay systems. No eelgrass is currently found in the central basin of Waquoit Bay (MassGIS 2003). The studies of Waquoit Bay describe the effects of watershed development, nutrient enrichment and algae proliferation on eelgrass habitat. These studies provide a reasonable record of other losses of eelgrass in shallow water embayments of southern Cape Cod, the islands and Buzzards Bay.

Martha’s Vineyard and Nantucket contain extensive eelgrass meadows. The enclosed embayments and northern shorelines are lined with eelgrass. Enclosed waters show signs of degradation, such as high epiphytic loads and macroalgae, that diminish eelgrass habitat quality. Cape Pogue was studied in 2002, and notable volumes of macroalgae, particularly *Codium fragile*, was observed mixed with eelgrass (personal observation). The 1994 eelgrass map did not note macroalgae occurrence in Cape Pogue (MassGIS 2003).

Buzzards Bay

The most detailed assessment of changes in eelgrass abundance for Massachusetts is a study from Costa (1988) of Buzzards Bay, but this study is dated and does not document current changes in eelgrass habitat. For the purposes of this report, the study of Buzzards Bay (Costa 1988) is summarized and important details are noted. Eelgrass was widespread in Buzzards Bay prior to 1930. Bay-wide eelgrass populations were devastated in 1930-1933 by the outbreak of wasting disease. Eelgrass slowly recovered from the late 1930s, and greatest increases in abundance occurred in the 1960s and 1970s. All areas, however, did not recover from the wasting disease episode.

Eelgrass covered 11,120 acres in 1988 (Costa 1988). Evidence documenting change of eelgrass through time is not complete, but data available suggests eelgrass abundance prior to the disease outbreak (in 1930s) was greater than the 1988 abundance. The 1994 map (MassGIS 2003) showed further loss of eelgrass coverage, with eelgrass covering 6,721 acres.

The cause of diminished eelgrass populations can be site-specific, but severe climatic events (e.g., icing and ice scour) and declining water quality are the biggest factors effecting eelgrass habitat in southeastern Massachusetts (Costa 1988). Particular embayments, however, have seen modest increases in eelgrass distribution in recent years. Costa (1988) studied 12 embayments to investigate temporal changes in eelgrass distribution, and MassGIS (2003) shows the 1994 distribution of eelgrass. The two data sources are summarized to provide additional detail on the changes in distribution and potential causes of changes (please see Costa 1988 and MassGIS 2003 for more detail).

Eelgrass disappeared from protected waters of upper estuaries in the Westport Rivers, Apponagansett Bay, Little Bay, Great Neck, Wareham Rivers, Sippican Harbor, Clarks Cove, Buttermilk Bay, Megansett and West Falmouth Harbor (Costa 1988; Hughes et al. 2002; MassGIS 2003). The loss in the upper estuaries are due to decreased water clarity from nutrient loading and increased epiphyte and algal cover. Increased recreational boat traffic may also contribute to decreased water clarity due to resuspension of sediments by propeller wash and shoreline erosion from wakes. Drift algae, frequently associated with nutrient loading, proliferated in the past couple of decades throughout Buzzards Bay. These algae species smother eelgrass seedlings, adult shoots, and available eelgrass habitat.

New Bedford Harbor, including Acushnet River and outer harbor waters, endured major physical changes (e.g., development of the port and construction of the hurricane barrier) and substantial chemical insults (e.g., PCBs, heavy metals, and sewage). These insults substantially reduced eelgrass populations and available eelgrass habitat, but recent eelgrass distribution has expanded in the outer harbor. Sewage treatment and combined sewer overflow control upgrades improved water quality in the harbor.

Outer estuarine waters and enclosed waters surrounded by limited watershed development tend to have relatively stable eelgrass beds. Substantial areas of the open Buzzards Bay coast are lined with eelgrass (MassGIS 2003). Nasketucket Bay, East Bay and West Island (Fairhaven), for example, are relatively undeveloped coastlines and contain consistent eelgrass beds. Lower portions of estuaries, such as Westport Rivers, Apponagansett Bay, Sippican Harbor, southern portion of the Cape Cod Canal, and West Falmouth Harbor, demonstrate relatively persistent eelgrass beds. Outer estuaries, however, that are adjacent to upper estuarine waters that show signs of eutrophication are vulnerable to further loss of eelgrass habitat.

SUMMARY

Eelgrass habitat is a critically important resource in Massachusetts waters. There are no long-term records that document the change in eelgrass abundance or quality. The recent DEP mapping project provided the first statewide coverage of eelgrass. The patchwork of historic information, targeted studies, and recent observations allows an evaluation of changes in eelgrass distribution. This evaluation, however, does not indicate changes in habitat quality. Historically there were substantial losses of eelgrass habitat in Massachusetts Bay and, more recently, large-scale losses were noted in Buzzards Bay and Cape Cod.

Embayments in Massachusetts Bay, including waters north and south of Boston, and western Cape Cod Bay tend to be well-flushed, cool and low in nitrogen. These systems generally provide suitable environmental conditions for stable eelgrass populations, and recent surveys document minor changes to eelgrass habitat. There are exceptions however, because impacts associated with physical disturbance, coastal development, and disease have diminished eelgrass abundance in areas of northern Massachusetts Bay.

Historic abundance of eelgrass was substantially diminished in enclosed waters of southern Cape Cod and Buzzards Bay. These estuaries tend to be shallow, semi-enclosed systems, with relatively warmer water temperature. Cape Cod and Buzzards Bay experienced substantial coastal and watershed development in the past several decades and septic systems are more widely used in this region, resulting in greater delivery of nitrogen to coastal waters. The shoreline of Buzzards Bay, southern Cape Cod, and the Islands supports extensive eelgrass abundance, but expanding watershed development, increasing nutrient loading and the widespread occurrence of algae (drift, attached and encrusting) raises concern of further degradation of eelgrass habitat.

Massachusetts has the greatest quantity of eelgrass of any New England state. Current statewide monitoring includes mapping eelgrass distribution at a three to five year cycle. Eelgrass mapping provides fundamental information on eelgrass presence, but eelgrass habitat is variable and the location of eelgrass changes through space and time. Environmental requirements of eelgrass and human-induced threats to eelgrass are well described. Water quality and direct disturbance to eelgrass beds are particularly important to eelgrass growth and survivorship, but current management approaches (e.g., state water quality standards and mooring field development) do not ensure the protection of eelgrass. The Massachusetts Estuaries Program, administered by Massachusetts DEP, is researching and developing site-specific data to manage nutrient loading to nearshore waters. This program can provide the basis for identifying water quality standards that will protect eelgrass habitat. The long-term sustainability of eelgrass habitat requires proactive conservation measures, including nutrient loading management and habitat protection.

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3. SEAFLOOR HABITAT AND MAPPING

A variety of physical, chemical and biological factors contribute to seafloor habitat type and quality. Substrate type, salinity, temperature, dissolved oxygen and water depth are important physical and chemical factors that affect habitat type, while biological factors such as the presence of particular animal and vegetation communities also contribute to the habitat type and quality. This section describes the types of subtidal (below mean low water) seafloor habitats, primarily defined by the predominant substrate type, but does not review all habitat types or species associations.

The description of seafloor habitat often relies on the assessment of surficial seafloor sediments. The geological composition of the ocean floor is highly variable throughout Massachusetts waters, with the most notable difference occurring north and south of Cape Cod. Glacial scour removed soft sediments from large regions north of Cape Cod leaving the Gulf of Maine with a highly heterogeneous seafloor composed of both soft and hard substrates. In southern Massachusetts, which is part of the middle Atlantic Bight, there is a similar range of substrate types but a higher proportion of sand environments. A large volume of research demonstrates that animal and plant distributions are often closely associated with substrate types; therefore different communities of organisms are generally associated with different substrate types. Table 1 lists major types of seafloor habitats in Massachusetts and some of their notable ecological functions.

Table 1: Seafloor habitat features in Massachusetts (adapted from Auster and Langton 1999).

SEAFLOOR HABITAT TYPES	ENVIRONMENTAL CHARACTERISTICS AND NOTABLE SPECIES ASSOCIATIONS*
Rock Ledge and Piled Boulders	- Deep interstitial spaces of variable sizes - Hard substrate provides attachment for a variety of vegetation and unique invertebrate assemblages (kelp, soft corals, anemone) - Fish, such as redfish, frequently congregate
Partially Buried Boulders	- Exhibit high surficial relief with little interstitial space - Valuable shelter for mobile species, such as redfish and tautog, and attachment surface for invertebrates
Cobble and Gravel with Epibiota Epibiota are creatures and plants living on seafloor surface.	- Attached fauna and flora, such as sponges and macroalgae, add spatial complexity to cobble substrate - Sediments and attached creatures provide microhabitats for diversity of creatures - Important nursery and fishery habitat for diversity of species (e.g., sea scallops, American lobster, Atlantic cod)
Cobble and Gravel	- Provide small interstitial spaces - Important settlement nursery habitat for variety of fishes and crabs (e.g., cod and lobster) - Important attachment habitat for invertebrates and fishery habitat
Shell Aggregates	- Complex interstitial spaces used for shelter - Invertebrates attach to shells
Biogenic Structure (on relatively smooth bottom)	- Biological growth – epifauna and algae – provide shelter and structure to mobile creatures on the seafloor - Burrows and depressions formed by mobile creatures are inhabited by many organisms
Sand	- Sand waves often form troughs and peaks, providing limited surficial relief - Organisms find shelter from currents and predation in troughs - Flounder species, surf clams and quahogs frequently associated
Smooth Sand or Mud	- Areas with little to no vertical structure – flat benthos - Support number of invertebrates, including unique species assemblages (cerianthid anemones, tube-dwelling amphipods, sea pens) and fishes (especially flatfish) - Important shellfish (e.g., soft-shell clam, razor clam) habitat

* Species noted are meant only as examples. Thorough studies on species associations are available, but this section is not a comprehensive summary of the ecological function of each seafloor habitat type. Seafloor habitats do not typically function independently; that is – many marine organisms require a range of habitat types throughout their life cycle. This list presents the habitat types by predominant substrate in isolation, but these substrate types frequently occur in combination, which imparts different ecological functions.

HUMAN-INDUCED IMPACTS TO SEAFLOOR HABITAT

There are many direct and indirect impacts to seafloor habitat associated with human activities. Watershed development contributes a variety of pollutants to coastal waters that influence the quality and function of a variety of seafloor habitats. Non-point and point sources of pollution have large scale impacts to seafloor habitats, especially in nearshore waters close to sources.

Direct disturbance from construction in ocean waters, such as pipeline installation, have localized impacts to seafloor habitats. The effects of fishing, including bottom-tending gear, has wide-ranging impacts (spatial and temporal) to seafloor habitats and the composition of fauna associated with habitats (Auster and Langton 1999). These and other anthropogenic impacts combine to degrade seafloor habitats and change the quality and function of the diversity of seafloor habitats in Massachusetts waters.

MAPPING AND MANAGING SEAFLOOR HABITAT

Coastal and fishery resource managers are frequently tasked with evaluating the impact of development projects or uses in the coastal zone without sufficient knowledge of the seafloor habitat types that may be impacted by proposed projects. Aside from the eelgrass mapping, the distribution, types and quality of subtidal seafloor habitats are largely unknown for Massachusetts. This lack of information hinders the management of marine ecosystems. An essential component of effective management is knowing the distribution of seafloor habitats, so that exemplary, unique, and sensitive habitat types can receive a higher level of resource assessment for permit review or even be subject to proactive protection measures.

In contrast with marine resource managers, terrestrial and freshwater managers have many types of maps that depict information vital to management decisions. For example, the United States Geological Survey (USGS) created topographic maps (scale=1:25,000) of the terrestrial portion of the United States. These maps depict elevation contours, infrastructure, hydrological features and forested areas. Marine resource managers lack this type of information, unless the site was previously examined for a proposed project. Currently, marine resource managers in Massachusetts only have a very coarse scale map (1:1,000,000) of sediment distribution (Poppe et al. 1989), higher resolution for small areas (e.g., one harbor) or completely lack any information on subtidal resources from which to infer the distribution and/or condition of seafloor habitats.

In the absence of spatially explicit information regarding the distribution and condition of seafloor habitat, marine resource managers are forced to rely on project specific resource characterizations to make management decisions. This leads to an uncoordinated, piecemeal assessment of the condition of the seafloor and its associated species.

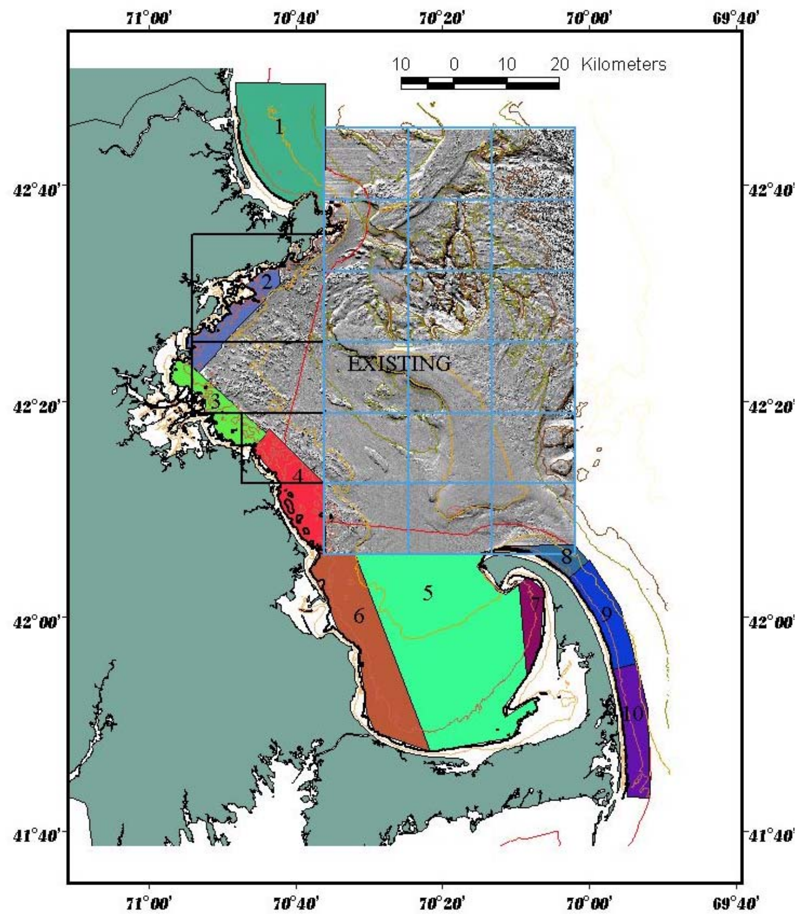

Figure 1: Map showing extent of current and proposed mapping for waters greater than 10 m depth in Massachusetts' Acadian province. Figure courtesy of Brad Butman, USGS.

Recent technological advances in the use of acoustics to derive information about the seafloor geology has made seafloor habitat mapping feasible for large areas. Seafloor geology and bathymetry were collected over large areas within and adjacent to state waters (Figure 1, Stellwagen Bank National Marine Sanctuary mapping; USGS 2003).

The type or quality of seafloor habitat encompasses more than geology and bathymetry. However, these physical data types are efficiently collected at large geographic scales and are fundamental data for subsequent assessment of animal and plant communities. Biological data is essential for the description of seafloor habitat. Seafloor habitat maps, showing seafloor substrate type, topography and species associations are a valuable planning tool to insure future protection efforts are habitat based and include representatives of all habitat types in a region.

STATUS OF ACOUSTIC MAPPING OF THE SEAFLOOR

The recent development and application of acoustic mapping systems, such as multibeam and side scan sonar, to map the distribution of seafloor substrates and bathymetry provides highly detailed images of the seafloor. These detailed maps are useful in determining the type and extent of seafloor habitats. Several large-scale mapping projects in Massachusetts are planned or underway.

The Massachusetts Office of Coastal Zone Management (CZM) is partnering with the US Geological Survey (USGS) to conduct seafloor mapping in selected areas of Massachusetts (using mitigation funds from a natural gas pipeline installation in Massachusetts Bay). Various types of acoustic instruments are used to measure seafloor topography, surficial geology (sediment distribution and bedforms) and the subbottom profile of various sediment layers. Two major sections of Massachusetts Bay were recently surveyed using acoustic instruments (Figure 1). Section 1 extends from Cape Ann to the New Hampshire border and was surveyed, using multibeam sonar, by Science Applications International Corporation (SAIC, Newport, RI). The survey boundary ends near the western edge of the University of New Hampshire's mapping of Jeffrey's Ledge (not shown). The comparatively shallower South Essex Ocean Sanctuary (which extends from Cape Ann to Boston Harbor; section 2) was surveyed using sidescan sonar and high-resolution seismic profiling by USGS in fall 2003. The mapping in the South Essex Ocean Sanctuary adjoined the northeast border of existing USGS mapping of Stellwagen Bank and western Massachusetts Bay (Figure 1). Sections 3 to 10 were delineated based on water depth and will be mapped as funds become available. The outcome of the ongoing and planned mapping is a comprehensive, seamless map of seafloor geology and bathymetry for Massachusetts Bay, Cape Cod Bay and outer Cape Cod. Plans are also developing for similar surveys of southeastern Massachusetts. The final map will not include shallow waters (i.e., <10m).

The US National Ocean Survey's Office of the Coast Survey (OCS) is responsible for maintaining and updating navigation charts, and they periodically survey major ports to obtain high-resolution water depth (bathymetry) and seafloor topography data. In a 2001 survey of Boston Harbor and approaches, the OCS obtained multibeam and sidescan sonar coverage of the seafloor. Sidescan sonar data from Boston Harbor will be processed into a map of surficial sediment distribution and bathymetry. The eastern edge of the Boston Harbor sidescan survey adjoins the western edge of Stellwagen Bank and western Massachusetts Bay mapping (Figure 1).

In addition to the Boston Harbor and approaches survey, OCS recently completed acoustic surveys of Gloucester Harbor, Woods Hole Harbor and a small section of the seafloor off the southeastern point of Monomoy Island. CZM and OCS are determining the possibility of analyzing the existing and future survey data to create seafloor habitat maps.

After an acoustic survey, biological and geological sampling of the seafloor is critically important to groundtruth or verify the interpretation of the acoustic data. Groundtruth sampling involves acquisition of a sediment core for sediment grain size analysis and a range of techniques (e.g., bottom photographs and/or grab samples) to obtain biological data. Processing biological and geological samples is time consuming and therefore, the production of a seafloor habitat map lags substantially behind the completion of the acoustic survey. Seafloor habitat maps of the recent acoustic surveys in Massachusetts Bay and Boston Harbor are planned to be completed in winter 2004.

SUMMARY

Seafloor habitats are a valuable component of the ocean environment in Massachusetts. The type, distribution and quality of seafloor habitat strongly influence the abundance of non-commercial and fishery species. Additionally, the productivity, biological diversity and functions of nearshore and offshore ecosystems are strongly affected by the quality of seafloor habitats. The ecological function of many seafloor habitats are well described, such as the importance of cobble habitat to American lobster and Atlantic cod and rock ledge to invertebrate communities. However, the relationships between seafloor habitats and biological communities is a field of discovery and research is required to understand the value and function of seafloor habitats and species assemblages. Furthermore, the distribution of these habitats is largely not known. Ocean resources planning is limited due to the lack of seafloor habitat maps. Nearshore-shallow waters and offshore-deep waters contain a variety of habitats and spatial information regarding the distribution and extent of these habitats is needed to improve ocean resources management. Massachusetts is actively pursuing opportunities to obtain seafloor habitat maps, such as the collaborative mapping of nearshore Massachusetts Bay by CZM and USGS, and Massachusetts Division of Marine Fisheries efforts to obtain mapping equipment, and the results of these endeavors will facilitate future monitoring, research, and management of seafloor habitats.

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5. SOFT CORALS, KELPS AND WATER COLUMN HABITATS

The following is a brief description of soft coral, kelp bed and water column habitats. This section highlights these habitat types because they support biologically diverse and productive marine communities. Additional habitats and environmental features are also important to sustain the function and values of Massachusetts' ocean resources, but are not described in this section. Overall, many other animal and plant species, distinct physical characteristics and chemical properties contribute to the diversity and productivity of ocean environment of Massachusetts.

SOFT CORALS

Soft corals are suspension feeding invertebrates; their feathery tentacles capture food particles in the water column. Soft corals are generally long lived, with very slow growth rates. It can take several hundred years to reach a height of several meters (Watling and Auster 2003), but their skeletons create microhabitats for a diverse array of smaller organisms. Soft corals are similar to reef building corals (such as tropical coral reefs), except soft corals have flexible skeletons. Soft corals are typically found in deep water and attached to hard substrates. However, some species were found in the Massachusetts region in water only 13 m deep (Theroux and Wigley 1998). These species may occur in deep waters of the Massachusetts coastal zone, particularly off the southeast coast of Nantucket.

The historical distribution and abundance of soft coral was likely reduced due to fishing gear impacts; soft corals are highly susceptible to disturbance by gear that touches the bottom (Koslow et al. 2001). Their slow growth rates imply that recovery from disturbance can be expected to take a very long time. In addition, because soft corals are sessile (attached to the bottom), larval dispersal is their only means of recolonizing after severe disturbance. One soft coral species, *Alcyonium* sp. in Massachusetts is also threatened by predation by an introduced nudibranch, *Tritonia plebia***.**

Little to no data are available on the distribution of soft corals in Massachusetts. Limited MWRA hardbottom monitoring from a 2002 survey identified one species of soft coral, *Gersemia rubriformis,* at 23 m depth. Long-term monitoring of communities on vertical rock ledges in the subtidal zone off the Nahant Marine Lab found soft coral communities (Allmon and Sebens 1988). The fact that these two studies observed soft corals demonstrates that these unique and sensitive species can occur in state waters and merit attention.

KELP BEDS AND SEAWEEDS

Kelp are brown algae that grow up to several meters in length. The most common species in our region are sugar kelp, *Laminaria saccharina,* oarweed, *L. digitalis* and shotgun kelp, *Agarum clathratum.* Kelp are generally found attached to stable rock substrates in cold waters. The distribution of kelp in Massachusetts is likely limited to subtidal rocky habitats north of Cape Cod. Kelps also attach to human-made structures, such as docks and piers. Unfortunately, the distribution and status of kelp beds are unknown in Massachusetts. Kelp are not part of any monitoring program.

Kelp beds are underwater forests that provide refuge for a diverse array of invertebrates and fish, especially juvenile fish. The holdfasts, or root like structures, provide microhabitats for small invertebrates, such as brittle stars and juvenile mussels. Kelps have one of the highest primary productivity rates in the world. They cycle nutrients and are an important food source for grazing echinoderms, mollusks, and crustaceans. Extensive kelp beds reduce current speeds and buffer upland areas from erosion or storm damage. They also provide shelter from physical stresses such as UV (ultra violet) radiation. In areas of the Gulf of Maine, kelp beds are being replaced by the introduced green algae (*Codium fragile* spp. *tomentosoides*; Harris and Tyrrell 2001).

Additional seaweeds species are found throughout Massachusetts coastal waters. A number of brown algae species, collectively known as rockweed, form a highly structured habitat and provide important ecological functions in nearshore waters. The red algae, Irish moss (*Chondrus crispus)* is also a valuable part of nearshore seaweed communities, and was traditionally harvested along many sections of the coast. For example, the south shore of Massachusetts had substantial populations of Irish moss that sustained a productive industry for years.

There is no data on the distribution of kelp beds or other seaweed-dominated habitats in Massachusetts. This productive nearshore marine habitat has not received adequate attention from monitoring or research programs; therefore, trends in abundance and distribution are not available.

WATER COLUMN HABITATS

Oceanographic features, such as currents, fronts and eddies, are dynamic, interactive and temporally and spatially variable. Massachusetts has semidiurnal tides, major and minor currents, variable fronts and eddies, and large and small riverine discharge. These features are important to ecosystem structure and function. The tidal flux in Massachusetts provides rapid exchange of nutrients, dissolved organic matter and detrital matter from coastal waters to offshore regions; riverine discharges greatly influence nutrient levels in coastal waters; the tidal range and flux affects oceanographic processes (e.g., currents, fronts, eddies, gyres, and seafloor geology) that are associated with the distribution and abundance of biological communities. Fish spawning and early life history development (eggs and larvae) are frequently associated with water column features, and the productivity and success of reproduction can be largely influenced by oceanographic properties. Water column habitats are poorly understood. To fully understand the function of the estuarine and marine environment in Massachusetts, a thorough understanding of pelagic habitats is needed.

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SEDIMENT AND WATER QUALITY

Coastal ecosystems are one of the most important resources of the Commonwealth of Massachusetts as they support a diversity of resources and human uses, such as rich nursery and fishing grounds, tourism, and shipping. They are also threatened by growing populations in coastal regions and the myriad of point-source and non-point source pollution problems associated with growing population centers. Numerous recent reports highlighted the concerns of excessive nutrient discharges and other contaminant inputs to coastal waters and the need to better understand such problems before these threats lead to deterioration of coastal ecosystems (NRC 1994; Howarth et. al 1996; Boesch et al. 2001).

1. WATER QUALITY IN MASSACHUSETTS COASTAL ZONE & SUMMARY OF MONITORING ACTIVITIES

Environmental quality of U.S. coastal waters continues to be a major concern as population centers continue to grow in coastal regions and effluent discharges from multiple sources enter the sea. Input of nutrients to coastal waters leading to eutrophication is one of the most serious concerns facing coastal managers as this problem increases on local and global scales. In spite of advances in wastewater treatment over the past two decades, non-point sources of contamination continue to present a challenge to managing coastal waters. In a recent report issued by the Pew Oceans Commission on marine pollution, a watershed approach to managing coastal waters was recommended as the best way to integrate management and monitoring of multiple point and non-point sources of nutrient input.

<u>Massachusetts DEP</u>

The Massachusetts Department of Environmental Protection (DEP), through its Division of Watershed Management, is responsible for monitoring the condition of the water resources of the Commonwealth to identify whether ambient waters are of sufficient quality and quantity to support multiple uses, and to report findings in watershed assessment reports; to identify causes and sources of water use impairments as a first step in identifying water management strategies; and to characterize existing and emerging problems and target implementation strategies. For coastal monitoring, DEP collaborates with other federal and state agencies, as well as local entities, including the National Estuaries Program, the MWRA, and the Massachusetts Office of Coastal Zone Management (CZM). Massachusetts has initiated a Marine Monitoring and Research Program (MMRP). Much of CZM's initial emphasis has been placed on gaining information necessary to implement Best Management Practices for the improvement of the ecosystem health of coastal embayments.

<u>National Estuaries Programs</u>

Coastal Massachusetts has benefited from several major initiatives in coastal water quality management through the National Estuaries Program. The Buzzards Bay Program and the Massachusetts Bay Program have comprehensive management plans developed for identifying and addressing water quality problems and their solutions. The Buzzards Bay Program was one of the first estuaries to be designated in the National Estuaries Program. From a water quality perspective, the greatest concern in the Buzzards Bay watershed is the nutrient and pathogen input from residential developments into small embayments through run-off and groundwater input. The Coalition for Buzzards Bay, a nonprofit organization, developed as a citizen-led advocacy, education and research group to facilitate implementation of the comprehensive management plan and improve the involvement and education of local citizens and town officials in understanding the Buzzards Bay watershed. The Coalition releases an annual State of the Bay report with recommendations for improving and restoring degraded areas of the watershed.

The Massachusetts Bays Estuary Program was designated in the late 1980s and was closely aligned with the court mandated improvements in wastewater treatment for the City of Boston and surrounding cities and towns. The coastal area covered by the program extends from the New Hampshire border to the tip of Cape Cod and includes five distinct regions – eight Towns on the North Shore, Salem Sound, Metro Boston, South Shore and Cape Cod. Each of these regions has a unique set of management issues but they also share similar goals in the action plan to improve water quality over the next decade. Current program efforts are directed at a better integration of monitoring programs throughout the region and tracking the implementation of different aspects of the comprehensive management plan.

Although the Narragansett Bay Project is largely based in Rhode Island and directed at improving the water quality of the bay proper, several Massachusetts communities are located in the Narragansett Bay watershed. Communities on Mt. Hope Bay share many of the concerns in water quality seen in Buzzards Bay and Massachusetts Bays. The recent establishment of the Mt. Hope Bay Project at the University of Massachusetts at Dartmouth is directed at a better understanding of nutrient loading and habitat loss in Mt. Hope Bay. This project should add valuable insights on the status of Mt. Hope Bay in relation to other coastal regions of Massachusetts.

<u>Massachusetts Division of Marine Fisheries Water Temperature Monitoring</u>

MarineFisheries has monitored bottom water temperature from 1982 to present to examine the effect of water temperature on lobster biology. This monitoring program has specific goals related to the American lobster but is also an important dataset for a variety of purposes. Water temperature is collected with programmable electronic recorders at various depths at nine coastal sites located north and south of Cape Cod. Monitors are exchanged annually via SCUBA and the data downloaded for analysis. The temporal starting point for each site's time series differs since monitors were purchased and deployed as funding allowed.

The longest time series of bottom temperatures is from Cleveland Ledge in Buzzards Bay that is located at 30 ft. The last monitor to be deployed in this series was at Rocky Point, off Plymouth, also in the 30 ft. stratum. The Manomet Point and Mars sites located in Cape Cod Bay are at 60 ft. and 120 ft. respectively. The Martin's Ledge (formerly at the *Romance* wreck site) off Boston Harbor and Buzzards Bay-South (Barge) sites are located at 70-80 ft. and provide data from the north-south extremes in our series. Three sites (<20') were added in summer 2001 at early benthic phase lobster suction sampling stations in Boston Harbor, Cape Cod Bay and Buzzards Bay.

To determine if there have been any trends in bottom water temperature in Massachusetts coastal waters over time, deviations from the seasonal time series mean temperature were calculated and plotted. Two sites, one shallow and one deep, that are representative of the range of water depths that are typically fished in the Massachusetts coastal lobster fishery were chosen north and south of Cape Cod, respectively. Temperature data are collated into seasonal means as follows: Winter (January – March), Spring (April – June), Summer (July – September), and Fall (October – December).

An examination of the deviations of seasonal mean water temperature at both shallow and deep locations north of Cape Cod (Southern Gulf of Maine) reveal that water temperature has generally been above average throughout the latter half of the 1990's and into the early 2000's. Similarly, seasonal mean water temperature has generally been above average throughout the latter half of the 1990's and into the early 2000's at both shallow and deep locations south of Cape Cod (Southern New England).

This warming trend is confirmed by surface water temperature data collected by the National Oceanic and Atmospheric Administration (NOAA) from 1922 to 2003 in Boston Harbor, Massachusetts. There has been a statistically significant increase in the annual mean surface water temperature in Boston Harbor over the last 80 years. In 2002, the annual mean surface water temperature in Boston Harbor was 13.9°C, a time series record high that is 5 degrees above the time series low in 1924, and 3.1 degrees above the time series mean 10.8°C.

MarineFisheries is concerned with the impact of increasing water temperatures on lobster along the Massachusetts coast; conclusions of the effect of temperature is yet to be determined. As the *MarineFisheries'* bottom water temperature time series continues to develop, *Marine Fisheries* intends to examine this trend in relation to lobster life history and commercial landings.

<u>Summary</u>

Improvement in water quality can be seen in many local embayments as wastewater treatment programs and point source control programs are targeted toward mitigation of contaminant problems. The MWRA has tracked improvement in indicators of water and sediment quality in its annual report "State of Boston Harbor". During the past decade, MWRA reports improvements in oxygen concentrations in near bottom waters of Boston Harbor, reductions in solid discharges to the harbor, reductions in metal discharges to the harbor, as well as other indicators of environmental quality. (http://www.mwra.state.ma.us/harbor/html/2002-09.htm).

These improvements are a positive sign for the quality of nearshore waters, but larger-scale influences (e.g., changes in water temperature and salinity) may alter environmental conditions. Systematic water quality sampling will track changes in conditions and provide quantitative data to develop management plans.

2. MAJOR DISCHARGES IN MASSACHUSETTS

The U.S. EPA has a permit database that includes National Pollutant Discharge Elimination System (NPDES) permit holders in Massachusetts. This section describes a subset of the entire database and identifies permits in coastal communities. Coastal Massachusetts communities were defined as municipalities that abut the coastal zone boundary as defined by CZM regulation (301 CMR 21.00). The available data did not allow an analysis of permits through time, so this assessment describes the 2003 status of the major and individual NPDES permits. As of 2003, there are 145 individual and 61 general NPDES permit holders in coastal Massachusetts communities.

Of the individual permits, 79 discharge directly to coastal waters and at least 33 of these are minor dischargers (less than one million gallons per day). The other individual permits discharge within the coastal watershed, including discharge to riverine systems.

Twenty-eight of NPDES permit holders are municipalities that discharge treated wastewater. An average of 472 million gallons of treated municipal wastewater directly enters tidal waters each day. Of these 28 facilities, two receive only primary treatment (Gloucester and Gosnold). All other facilities have at least secondary wastewater treatment.

There are ten large power-generating facilities that together are permitted to withdraw and discharge up to 4.5 billion gallons of cooling water every day from coastal waters. The discharged cooling water can be heated from 83 to 105˚F (28-41˚C) and can be 20 to 32˚F (-7-0˚C) greater than the ambient water.

Only eight major industrial dischargers in the coastal zone were retrieved by the search engine of EPA's PCS database. This is an under-representation of existing industrial discharges (e.g., Gillette was not included in the database and oil terminal permits were seriously underrepresented, Callaghan personal communication) and limit the description of industrial discharges to Massachusetts waters. Of the incomplete list of industrial discharges, five are stormwater discharges from industrial sites, two are process water discharges, and one is a cooling water discharge.

From 1992-2002, 228 individual NPDES permitted discharges in coastal Massachusetts communities were ended, either because the waste stream was consolidated, the company went out of business, or the project ended.

3. CONTAMINANT DISTRIBUTIONS IN SEDIMENTS AND SHELLFISH ALONG THE MASSACHUSETTS COAST

Regional studies of Massachusetts coastal waters have documented the spatial distribution of several classes of contaminants, including trace metals, chlorinated pesticides, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs) in sediments and biota (National Research Council 1995; McDowell 1997). The relationship between contaminant inputs and the distribution of contaminants in sediments and biota largely reflect a gradient of near-shore areas, especially urban and industrialized areas, having the highest levels of contamination, and offshore areas having significantly lower concentrations.

The first U.S. Mussel Watch program (1976-1978) provided a regional assessment of contaminant distribution in bivalve samples from New England waters (Farrington et al. 1983; Goldberg et al. 1983). Data collected in this program documented the strong urban influence on contaminant distribution in mussel samples for both trace metal and organic contaminants. A recent review of a decade of data collected in the Mussel Watch component of NOAA's National Status and Trends Program (mid 1980s to mid 1990s) concludes that the concentrations of contaminants in bivalve samples are declining for many classes of contaminants (O'Connor 1998). Exceptions to this general conclusion are reflected in the data for organic contaminants and lead particularly at stations in urban areas such as Boston Harbor.

To a large extent contaminant distribution in sediments and biota reflect not only contemporary inputs but also a history of industrial activity. For example, chromium contamination in Salem Harbor (MA) - reflects a history of inputs from the tanning industry (NOAA 1991). Concentrations of other trace metals are elevated at other locations – Boston Harbor and Quincy Bay – and reflect a pattern of wastewater input and other industrial sources of contaminants to shallow water embayments (NOAA 1989; 1991). Hydrocarbon inputs may also vary spatially and temporally as a result of chronic municipal discharges, agricultural practices, oil spills and other point and non-point sources. In Massachusetts coastal waters, there are numerous locations that have received inputs of petroleum hydrocarbons from both chronic discharges and accidental spills (Boston Harbor, Buzzards Bay, etc.) (MacDonald 1991; Menzie-Cura & Associates 1991; NOAA 1991). The use of chlorinated pesticides in agricultural practices has declined since the early 1970s but traces of pesticide residues have been reported at locations within the Gulf of Maine with inputs from agricultural runoff (Hauge 1988; Larsen 1992). For NOAA National Status and Trends Mussel Watch samples, elevated concentrations of aromatic hydrocarbons, chlorinated pesticides, and other chlorinated hydrocarbons were noted in bivalve samples, especially in urban harbors and industrialized areas (NOAA 1989; Sowles et al. 1992).

Trophic transfer of contaminants to higher level predators and the human consumer are generally most significant for lipophilic contaminants such as chlorinated hydrocarbons, and other persistent contaminants. Shellfish closures and advisories based on chemical contamination are relatively few but include some examples from the New England coast, notably PCB contamination in New Bedford Harbor and dioxin contamination in Maine (McDowell 1997).

4. MONITORING PROGRAMS FOR THE MASSACHUSETTS COAST

Monitoring water and sediment quality is challenging. There are many programs within the region, nation, and worldwide that provide guidance on developing monitoring programs. When designing a monitoring program to assess environmental changes in coastal resources, three basic questions need to be addressed (NOAA 1998):

1. Are environmental conditions improving or deteriorating over space and time? If so, where and when?
2. Are changes related to human activities? Do some activities have a greater impact than others?

3. What actions can best correct existing problems or prevent future problems?

Monitoring programs for measuring the fate and effects of chemical contaminants in coastal ecosystems should be designed and executed to provide meaningful information on: (1) spatial distribution of contaminants; (2) temporal variability in contaminant distributions, as a result of both natural variability and changes in chemical use patterns or pollution abatement; and (3) the relationship of contaminant inputs to ecological consequences, including habitat alterations of valuable resources, and human health concerns. Current state and federal monitoring efforts in coastal waters of Massachusetts, however, are too limited in scope (both spatially and temporally) to meet these goals.

Ecological effects of contaminants in coastal environments include impairment of feeding, growth, development, and recruitment that may result in both alterations in reproductive and developmental success and changes in community structure and dynamics. The human health concerns of contaminated resources are obvious. Yet, it is difficult to ascertain the relationship between chronic responses of organisms to contaminated habitats and large-scale alterations in the functioning of marine ecosystems as well as large-scale contamination of fishery resources. The sensitivity of early developmental stages, the impairment of reproductive processes, and the long-term effects on populations suggest that chronic exposure to many contaminants may certainly alter the dynamics of populations, including populations of valuable commercial resources.

To better understand the fate and potential effects of contaminants in the Gulf of Maine ecosystem, the following parameters are often evaluated:

1. Define the sources of contamination for specific contaminants and determine the relative contribution of different point and non-point sources to loading of individual compounds. An inventory of every compound is not feasible but an assessment of a few highly persistent compounds such as PCBs, PAHs, and the polychlorinated dibenzodioxins (PCDDs) should be possible.
2. Determine the persistence, degradation rates, and biogeochemical cycling of specific contaminants in sediments at selected sites along the Massachusetts coastline. Determine the flux of specific compounds and the body burdens of resident organisms.
3. Using populations of indigenous bivalve species or demersal fish or lobster populations during seasons with limited migrations, define patterns of contaminant exposure and the relationship between exposure and changes in physiological condition or other parameters of biological change.

Such a program could lead to a better understanding of the causal relationship between input of specific contaminants and the relative ecological and human health risks associated with such inputs. Specific management issues that must be addressed, especially in consideration of the ecological and human health risks associated with chemical contamination, are the development of contaminant guidelines for benthic habitats. These should include consideration of guidelines for the disposal of contaminated dredged materials, development of interim sediment criteria, and the routine determination of concentrations of contaminants in harvestable resource species.

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THE OCEAN AS A PUBLIC TRUST RESOURCE

Few places on earth are as completely public as the open ocean. The sea is no one's private property; rather, it is a commons that belongs to all the people, through ownership by the respective coastal States extending three (nautical) miles from shore. While many are aware that the territorial waters of Massachusetts are actually state property, it is less well known that such property is impressed with a higher order of stewardship responsibility than is generally the case with publicly owned buildings or land. Our ocean is thus a uniquely protected resource, and the Commonwealth has a powerful legal tool at its disposal to keep it so – the Public Trust Doctrine.

As ancient as western civilization itself, the Public Trust Doctrine is thought to originate in the second century writings of a Roman jurist who codified the pronouncements of Greek philosophers, much of which in turn was codified into Roman civil law by the Emperor Justinian circa 530 AD. Thus the *Institutes of Justinian* came to include the following passage at Book II, c.1, s.1:

> "Et quidem naturali jure communia sunt omnium haec, aer, aqua profundus, et mare et per hoc littora maris". [By natural law itself these things are the common property of all: air, running water, the sea, and with it the shores of the sea.]

Roman civil law influenced the jurisprudence of many European nations and particularly the common (i.e., judge-made) law of England after the Magna Carta. The English courts of that era firmly embraced the notion that while the Crown generally had complete powers of ownership over the realm, any lands lying seaward of the high tide mark were an exception: such lands, the so-called "tidelands", were held *in trust* for the common benefit of the public, for commerce, fishing, and other activities in which all citizens were free to engage. This same doctrine was brought to the American colonies, passed on to the thirteen original states after the Revolution, and ultimately inherited by every coastal state as it came into the Union (subject to the powers delegated to the federal government by the US Constitution). Today, the centuries-old principle of sovereign ownership of tidelands subject to a public trust is generally acknowledged to be among the most important and far-reaching in American coastal law.

Two key factors lend credence to this assertion. First, through its ownership of *public property rights* between the high tide mark and the three-mile limit, each coastal state has far greater latitude in protecting societal interests than is generally the case for dry land, most of which is private property over which government control is based only on the "police power" to protect public health, safety, and general welfare. Second, American courts for over three centuries now have reiterated that in navigable waters the *trust,* as the word implies, is so solemn an obligation of government that it cannot be divested, even as title to the soil below might be conveyed to private parties in certain circumstances. As the United States Supreme Court put it, in the landmark case of *Illinois Central R.R. Co. v. Illinois (1892):* "…the state can no more abdicate its trust over property in which the whole people are interested, like navigable waters and soils under them, so as to leave them entirely under the use and control of private parties….than it can abdicate it[s] police powers in the administration of government and the preservation of peace".

Over the years a number of other landmark cases, in both federal and state courts, have made it clear that the "trust" to which the doctrine refers is a real trust in the legal sense of the word. It has all the key elements of a binding instrument, as described in Putting the Public Trust Doctrine to Work (2nd Ed.), a major treatise on the subject prepared in 1997 by the Coastal States Organization (CSO):

> There are trust assets, generally in the form of navigable waters, the lands beneath these waters, the living resources therein, and the public property interests in these trust assets. The trust has a clear and definite beneficiary: the public, which includes not just present generations but those to come. There are trustees: the State Legislatures, which often delegate their trust powers and duties to State coastal commissions, land commissions, or similar state agencies, as well as municipalities. These trustees have a duty to protect the trust. There is a clear purpose for the trust: to preserve and continuously assure the public's ability to fully use and enjoy public trust lands, waters and resources for certain public uses.

The CSO treatise further points out that although a common core of principles exists, each state has the authority to uphold the public trust in a manner consistent with its own views of justice and policy. As a result, "…there is really no single Public Trust Doctrine; rather, there are over fifty different applications of the doctrine, one for each State, Territory or Commonwealth, as well as the federal government".

Here in Massachusetts, the Public Trust Doctrine has had a profound influence on our law of the seashore, beginning with the Colonial Ordinances of 1641-1647.[8] In that early legislation, the Massachusetts Bay Colony decided to encourage construction of wharves for maritime commerce by giving shorefront property owners a blanket grant of title to the adjoining "flats", the strip of tidelands lying between the high and low tide marks (but only to a maximum width of 100 "rods", about 1650 feet, from the high tide mark). That decision converted Massachusetts into a so-called "low water" state, the first of five that would eventually choose to move the seaward boundary of private littoral property from the high to the low water mark. Mindful of their duty as trustees, however, the colonial legislators specifically reserved for the public the right to continue using the intertidal area for three activities in which the livelihood of virtually every inhabitant depended – *fishing, fowling, and navigation.*[9] In expressly retaining state ownership of these all-important property rights, the 1641-47 enactment became the first statute in the nation to codify the Public Trust Doctrine, albeit to a limited extent.

It is important to realize that the Colonial Ordinances did not in any way change the legal status of submerged lands, i.e. the tidelands lying seaward of the low water mark. Such

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[8] For a recent and authoritative review of public trust law pertaining to Massachusetts waterways, see John A. Pike, "Waterways and Wetlands", Real Estate Title Practice in Massachusetts, chapter 15 of a 2-volume set published by Massachusetts Continuing Legal Education, Inc. (2003).

[9] Note that the reserved easement also covers the "natural derivatives" of the public rights of fishing, fowling, and navigation, in particular the right to pass freely over any intertidal areas in order to exercise these reserved public rights. Further details on the scope of public rights in the intertidal zone are provided in a pamphlet published by the Massachusetts Attorney General entitled "Public Rights/Private Property: Answers to Frequently Asked Questions on Beach Access".

offshore areas continued to be state property and the rights held in trust for the public remained undiminished, as they generally are today -- the entire "bundle of sticks" associated with ownership in fee simple absolute (subject only to the paramount authority of the federal government to regulate certain maritime activities pursuant to the Commerce Clause of the US Constitution). This was affirmed almost a century ago by the state Supreme Judicial Court (SJC) which, in the case of *Home for Aged Women v. Commonwealth (1909)*, stated that "it would be too strict a doctrine to hold that the trust for the public, under which the State holds and controls navigable tide waters and the land under them, beyond the line of private ownership, is for navigation alone. It is wider in its scope, and it includes *all necessary and proper uses, in the interest of the public* (*emphasis added*)". Simply put, the scope of the trust in state-owned ocean resources is as broad as the public interest itself.[10]

More than 200 years passed before Massachusetts reached its next major milestone in the evolution of public trust law. In this period, stewardship of tidelands was characterized primarily by two activities: passage of additional "wharfing statutes" allowing individual upland proprietors to place fill and/or construct piers on submerged lands, subject to appropriate conditions and compensation for any property interest granted; and occasional court rulings to clarify the extent of residual public rights *vis-à-vis* private prerogatives under these enactments (read together with the Colonial Ordinances). By the turn of the 19th century, of course, the heyday of shipping had arrived and with it an explosion of waterfront development in all the major ports of the Commonwealth – so much so that legislative attention to water-borne commerce began to shift from facilitation to regulation. This commenced in 1837 with the imposition of statutory "harbor lines" to prevent undue encroachment of fill and structures into the waters of Boston Harbor, a process later extended to all major harbors after being upheld – even as it applied to building within privately owned flats – by the SJC in the famous case of *Commonwealth v. Alger (1851).*

Fifteen years later, with the boom in waterfront development continuing, the legislature decided that it could no longer handle the volume and complexity of requests for permission to build on tidelands, nor deal effectively with increasing levels of unauthorized construction. This led to the passage of Chapter 149 of the Acts of 1866, codified as Chapter 91 of the Massachusetts General Laws and later dubbed the Public Waterfront Act. The first of its kind in the nation, this statute officially delegated the bulk of responsibility for day-to-day stewardship of all tidelands (as well as Great Ponds and non–tidal waterways covered by the Public Trust Doctrine) to the agency the legislature had previously created to draw harbor lines -- the Board of Harbor Commissioners. Thus began the era of waterways regulation *outside* the halls of the State House, by the executive branch of Massachusetts government rather than the legislative branch.

Apart from effecting a general transfer of decision authority, M.G.L. c.91 included two interesting provisions that emphasized the *gravitas* of the public trust. First, the statute indicated that the legislature would continue to exercise sole authority to approve two types of

[10] In particular it seems clear that conservation of natural marine resources is a trust-protected interest, in view of Article 97 of the Massachusetts Constitution that articulates "the right of the people to clean air and water, freedom from excessive and unnecessary noise, and the natural, scenic, historic, and esthetic qualities of their environment".

development likely to infringe most significantly on public navigation rights: piers and other structures extending beyond a statutory harbor line, and the first fixed-span bridge upstream of the mouth of a waterway. Second, the statute required that any license issued for work in submerged lands owned by the Commonwealth must carry the signature of the Governor – a practice that lives on to this very day, after nearly 140 years in which approximately 20,000 waterways licenses have been issued by a variety of successor agencies.

In the years following World War II this licensing program almost came to an unexpected end, due to a dispute with the federal government over whether the states were indeed the owners of submerged lands and thus the ultimate trustees of the public's rights therein. The dispute was triggered in 1945, when President Truman asserted to the world that the United States had exclusive jurisdiction over seabed minerals and other resources of the continental shelf. Federal officials interpreted the Truman Proclamation as a claim not only of sovereignty against foreign nations but also of title against the individual states, effectively placing into federal hands what the states had been managing for two centuries. A legal challenge to this proclamation by the state of California was rejected by the U.S Supreme Court, and in 1950 the Court affirmed in a series of other cases that the federal government, not the individual states, owned and controlled a significant expanse of submerged lands and ocean waters. The dispute persisted, however, with the states turning to the U.S. Congress to resolve the matter. In 1953 Congress decided, with the agreement of newly-elected President Eisenhower, to avert the possibility of interminable litigation by passing the Submerged Lands Act to restore state ownership in submerged lands out to three miles.

The latest chapter in Massachusetts story of tidelands stewardship began to unfold in the late 1970s. General concern for coastal issues had increased greatly throughout the decade, culminating in 1978 with the formal establishment of the state Coastal Zone Management (CZM) Program that included, among other things, three key initiatives affecting use of the ocean. These were:

* the first-time promulgation of written regulations to guide further Chapter 91 licensing and permitting by (what is now) the Department of Environmental Protection (DEP);

* adoption of similarly-new regulations by (what is now) the Department of Conservation and Recreation (DCR) to implement the 1970 Ocean Sanctuaries Act (M.G.L. c.132A), which mandated preservation of the ecology and appearance of five specific areas of the Massachusetts territorial sea [11]; and

* adoption of extensive revisions to the DEP regulations implementing the Wetlands Protection Act (M.G.L. c 131, s.40) in coastal resource areas, including specific performance standards governing activities in Land Under the Ocean.

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[11] Note that the Ocean Sanctuaries Act did not establish an additional approval process. Rather, it called for the modification of existing applicable permitting programs, acting in consultation with DCR, to incorporate the prohibitions and standards of the law. Thus, as a practical matter, the waterways regulation program that implements Chapter 91 is the principal vehicle for implementing the OSA as well.

Taken together, this initial group of state regulations established at least a strong foundation for more coherent management of ocean uses, both near and far from shore.

Very soon thereafter, the Public Trust Doctrine was further elaborated in a momentous decision by the SJC in the so-called Lewis Wharf case, *Boston Waterfront Development Corp. v. Commonwealth (1979).* Here, the court was presented with the question of whether the public trust was terminated in law when tidelands were buried in fact as a result of authorized filling – which had been the universal assumption for the past two centuries. The court's definitive answer was that the public's property rights in formerly submerged tidelands are not so easily extinguished. After an extensive review of prior case law, the court declared that even though the legislative grant in question was 150 years old, it was still impressed with an "implied condition subsequent" that the property continue to be used for a public purpose.[12] These words ushered in a new era in tidelands regulation, marked by three milestone events:

* in 1981 the *Boston Waterfront* ruling was followed by another groundbreaking analysis in *Opinion of the Justices to the Senate*, in which the court expanded on the obligations of tideland stewardship in stating that any transfer or relinquishment of property rights held by the Commonwealth was subject to a rigorous five-part test – a test that it was evident few if any of the old "wharfing statutes" could satisfy;

* in 1984, jurisdiction of the waterways regulation program "came ashore" when the legislature amended Chapter 91 to require licensing of any new (or previously unauthorized) change of use or structural alteration on filled tidelands, with heightened scrutiny mandated for nonwater-dependent projects; and

* in 1990, DEP completed a comprehensive overhaul of its waterways regulations to more effectively promote water-dependent uses and associated public access, when licensing projects on both filled and flowed tidelands.

Thus, in the course of a single decade Massachusetts had put in place a comprehensive scheme for controlling near-shore development, and in doing so had remained at the national forefront of progressive law-making based upon the Public Trust Doctrine.

But what of the "great watery expanse" above the tidelands lying farther offshore? In this domain very little has changed in the substance of Chapter 91 regulation in the last thirty years or even since the 1800s, simply because proposals for major construction, unattached to land, have been few and far between. Rather, the focus of ocean stewardship has been on developing a separate branch of public trust law and regulation to control fishing, shipping, and other traditional forms of water-borne commerce that are "mobile" in nature (in contrast to "stationary" uses and structures within the purview of Chapter 91). A prime example in this regard has been the efforts of the Department of Marine Fisheries, charged by M.G.L c. 130 with responsibility for protecting and preserving the living marine resources of the Commonwealth (especially commercial and recreational finfish and shellfish).

[12] As stated even more eloquently in a landmark public trust case decided by another state Supreme Court: "That generations of trustees have slept on public rights does not foreclose their successors from awakening". *Arizona Center for Law in the Public Interest v. Hassell (1991).*

Yet times are changing, and offshore areas are increasingly being seen not only as a highway of commerce but also as prime building space, for facilities ranging from wind farms and aquaculture pens, to pipelines and communication cables, and to emerging technologies that desalinate tidewater, harness wave energy, and otherwise seek to meet basic societal needs.[13] These new development proposals have exposed a major gap in our current management framework, which relies on traditional regulatory tools that are purely reactive and do not afford a means of planning for the disposition and use of the public's ocean assets. For example, the Chapter 91 regulations generally exclude nonwater-dependent development from open waters, but water-dependent projects are eligible for licensing without further differentiation on the basis of type, size, location, environmental impacts, or other relevant parameters; and even prohibited nonwater-dependent projects can seek a variance if necessary to accommodate an "overriding municipal, regional, state, or federal interest". In Ocean Sanctuaries the bar for allowable uses is set a bit higher, in that a (very) short list of activities is categorically prohibited by the statute itself. Beyond this, however, virtually everything is allowable subject to a demonstration of "public convenience and necessity" – a test that has yet to be defined in more specific or transparent terms and, as a consequence, has seldom operated as a tool to help the state, developers, and the public recognize in advance what types of project are generally appropriate.

In terms of performance standards to be applied on a case-by-case basis, the roster of Chapter 91/OSA provisions addressing offshore impacts is equally thin. Projects may not significantly interfere with public rights of navigation and fishing (which, interestingly, includes "the right to protect habitat and nutrient source areas in order to have fish, fowl, and marine plants available to be sought and taken"), and the standard is elaborated somewhat by specific restrictions. For example, projects are proscribed from extending into existing channels so as to impede free passage or impair sight lines required for safe navigation; also prohibited is the elimination of a traditional fishing or fowling location used extensively by the public. Beyond this, however, little or no guidance is available on the mitigation of other potential adverse effects, such as those that might substantially alter the ecology or appearance of an Ocean Sanctuary. Although preventing such alteration is the stated intent of the Ocean Sanctuaries Act, no performance standards or criteria have been promulgated as yet to implement this mandate.

Accordingly, the next chapter in the codification of the Public Trust Doctrine has yet to be written. As concluded by the Task Force, this chapter should focus on the need for coherent planning as the key to improved, ecosystem-based management of ocean resources. This challenge that can be met if tidelands trust principles are applied in productive combination with the resource management tools we have developed in the past, through experience with parklands and other natural resource areas in government ownership. The time of opportunity to extend this longstanding tradition of effective stewardship is at hand.

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[13] Among the more futuristic uses of the ocean being contemplated is that of directly counteracting global warming, as reported in a recent news item: "…the scientists backed more way-out systems for reflecting the sun's rays back into space. Plan A would float thousands of bubble-making machines across the world's oceans to send huge amounts of salt spray into the atmosphere. The trillions of tiny droplets would make the clouds bigger, whiter, and more reflective – enough, in theory, to shut down several decades worth of global warming". See "Scientists Use Creativity to Fight Global Warming", Boston Globe, p. C1 (January 20, 2004).

POLICY

Massachusetts Ocean Management – Introduction to Policy

The people of Massachusetts, the so-called "Bay State", have a long shared history and tradition associated with our ocean. Whaling, fishing, and importing were the economic foundation of the Massachusetts Bay Colony in the 17th Century. Even today, our port areas and ocean waters are critically important to the major industries of fishing, tourism, and commerce. Massachusetts continues to house one of the largest fishing industries in the nation, with the total value of marine fisheries landings and expenditures made by recreational anglers within the Commonwealth generating about $2 billion per year and supporting over 80,000 jobs. Today, over half of the full-time residents in Massachusetts live within 50 miles of the ocean, and these numbers do not account for the enormous influx of visitors and tourists that flock to our coastal communities during the summer months

Currently, the permitting process for projects in Massachusetts coastal waters can be quite complex. A wide range of applicable laws and regulations are intended to protect a diverse mix of resources and sometimes-competing uses, and the statutes themselves date from the earliest colonial era and beyond to the present. For example, as described above in the section on the Public Trust Doctrine, the Public Waterfront Act can trace its heritage from Roman law through English Common Law, and remains a key component of coastal regulatory review to this day. In addition to state law, a range of federal, regional, and local regulatory requirements may also apply. Most large coastal or offshore developments in Massachusetts will require action by numerous agencies, of which critical processes are outlined below.

The administrative interaction among federal, state, regional, and local reviews is often quite complicated, and coordination of the various review processes can be a challenge in and of itself. In addition, some federal laws (such as the Clean Water Act) delegate administration of aspects of the law to the state, and some state laws (such as the Wetlands Protection Act) delegate aspects of implementation to municipalities.

To analyze the array of statutes, regulations and other statutes that affect development, use and protection of the state's oceans, the Task Force established a Policy Working Group. This working group held various meetings with state agency program managers, industry representatives, the regulated community, advocates and other stakeholders to identify the strengths, shortcomings, and gaps within the Commonwealth's existing ocean management system.

In addition to developing discrete recommendations to improve upon the Commonwealth's existing ocean management programs, the Policy Working Group served to inform the entire Task Force in its efforts to develop a comprehensive framework for ocean management. In November, the Policy Working Group merged with the Frameworks Working Group. This section of the report summarizes the research on statutes, regulations and policies that was carried out in support of the work of this combined Policy/Frameworks Working Group.

The geographic scope of the Ocean Management Task Force and the Commonwealth's management authority is limited to state jurisdiction, which generally extend three miles offshore from the mean low tide line. Federal waters extend from the limit of state waters to 200 miles offshore, an area known as the exclusive economic zone. While the state holds the legal interest in the ocean generally three miles off shore, it is important to note that the federal government retains significant legal authority over activities in state waters.
The Task Force was convened to examine issues with the state regulatory system, and therefore is not evaluating federal law, although the Task Force has reviewed and included recommendations on how the state implements its delegation of authority from certain federal statutes. The summary below is intended to provide a quick review of the key statutes most likely to apply to large coastal projects. Several federal review processes that operate without delegation to the state are critical to the planning, design, review, and implementation of projects in state waters, and thus are included in this summary for informational purposes.

Massachusetts Statutes, Regulations and Policies relating to Uses of the Ocean

Massachusetts Environmental Policy Act (MEPA) (M.G.L. c. 30 ss 61-62H and 301 CMR 11.00)

MEPA ensures that proponents study alternatives to proposed actions and avoid, minimize, and mitigate environmental impacts of proposed actions. MEPA review is not a permitting process, but rather it is an information-gathering process that precedes final action by state permitting agencies. MEPA applies when a proposed project meets or exceeds a filing threshold and requires a state agency action. The proponent files an Environmental Notification Form (ENF) with the Secretary of Environmental Affairs, which begins the public environmental review process. The Secretary receives comments, holds scoping meetings, reviews the ENF, and then issues a decision on whether further MEPA review is required. If further review is required, the Secretary specifies what issues require further analysis and the proponent prepares an Environmental Impact Report (EIR), which is then filed and undergoes another public comment period. EIR review is usually a two-step process, with Draft and Final EIRs required. After the Secretary determines that a Final EIR adequately complies with MEPA (or immediately in the case when no EIR is required), state agencies may take final permitting decisions on the project. The state permitting agencies must make "Section 61 Findings" for any project for which an EIR is completed. The Section 61 Findings essentially incorporate the mitigation and analysis from the EIR process into the state permitting decisions.

MEPA ensures that the public has input into the environmental review process and that state agencies have adequate information with which to conduct their permitting reviews. Because MEPA review precedes permitting and encourages comment from all public and private interested parties, the MEPA process often becomes the primary forum in which controversial issues are raised and addressed and in which agency and public comments are coordinated and incorporated into project design. MEPA also serves as the primary vehicle for coordinating the state review process with the federal NEPA process and regional review processes with the Cape Cod Commission.

Public Waterfront Act (M.G.L. c 91 and 310 CMR 9.00)

Commonly known as Chapter 91 and administered by the Department of Environmental Protection, this law protects the public's rights to access the waterfront for use and enjoyment of waterways of the Commonwealth, and codifies the Massachusetts version of the Public Trust Doctrine into statute. The focus of Chapter 91 often involves waterfront development issues, where the Chapter 91 regulations promote preservation of tidelands for water-dependent uses requiring direct access to the water, and preserve public access when tidelands are developed privately. However, it is important to remember that Chapter 91 also governs lands owned by the Commonwealth and held in trust for its citizens out to the limits of the Territorial Sea. For infrastructure, such as submarine pipelines and cables, the vast majority of the project subject to Chapter 91 jurisdiction lies in the subtidal areas seaward of the immediate area of the shoreline. Chapter 91 also sets fees for the occupation of tidelands. These fees have remained constant since the 1970's, and may appropriately be thought of as "rent" paid for the physical occupation of Commonwealth trust lands.

Ocean Sanctuaries Act (M.G.L. c 132A, ss 12A-16F, 18 and 302 CMR 5.00)

Currently, much of the Territorial Sea is included within one of the five designated Ocean Sanctuaries. The Act is administered by the Department of Conservation and Recreation (DCR), and prohibits activities that may significantly alter the ecology or appearance of the ocean, seabed, or subsoil of a designated sanctuary. The prohibitions may be waived (except within the Cape Cod Ocean Sanctuary) upon a finding by DCR that the project meets a six-part test of "public necessity and convenience." Projects that are below MEPA filing thresholds and projects that receive Chapter 91 licenses are presumed to comply with the Act. There is no separate permitting process associated with the Act. DCR review pursuant to the Act is incorporated into the MEPA and Chapter 91 review processes.

Wetlands Protection Act (M.G.L. c 131 s 40 and 310 CMR 10.00)

The Act is administered by local Conservation Commissions and DEP and ensures protection of wetland resources, including all coastal areas between Mean High Water and the limits of the Territorial Sea. The regulations require avoidance, minimization, and mitigation of impacts (including impacts to aquatic vegetation, flood control, and fisheries and wildlife habitat), and establish performance standards that define levels of impact that a project cannot exceed. For projects that meet the performance standards, local Conservation Commissions may issue an Order of Conditions specifying under what conditions a project may proceed. The applicant or any 10 citizens may appeal the local Order to DEP, which then issues a Superseding Order confirming, modifying, or overturning the local decision (a further appeal to an adjudicatory process is possible). For projects that do not meet the performance standards, a proponent must obtain a variance from the regulations from DEP, upon a demonstration that the project meets the tests for a variance. The variance tests include provisions that the project serves an "overriding public interest," that there are no feasible alternatives to the project, and that the project design incorporates substantial mitigation for impacts to wetland resources.

Clean Water Act, Section 401 Water Quality Certification (33 USC 1341 et seq., s 401; M.G.L. c 21 ss 26-53 and 314 CMR 4.00 and 9.00)

The Section 401 process is administered by DEP. The review ensures that projects proposing discharge of fill or dredged materials into jurisdictional wetlands comply with Massachusetts Surface Water Quality Standards, the Massachusetts Wetlands Protection Act, and otherwise avoid, minimize, or mitigate impacts to areas of Massachusetts subject to Section 401. Section 401 applies to any project that is subject to federal regulation under the Clean Water Act. If the project results in minimal fill within wetlands, the local Order of Conditions can also serve as the Section 401 Water Quality Certificate; otherwise, an individual permit review process by DEP is required. Consultation between DEP and the Division of Marine Fisheries usually occurs during the Section 401 review process to ensure that impacts to finfish and shellfish and their habitat are minimized.

Coastal Zone Management Act (16 USC 1451 et seq and 15 CFR 930; M.G.L. c 21A ss 2, 4 and 301 CMR 20.00)

The federal Coastal Zone Management Act encourages states to regulate development within their defined coastal zones and grants the power of Consistency Review to states with federally approved Coastal Zone Management Plans (CZMP). In Massachusetts, the Office of Coastal Zone Management implements the state CZMP and ensures that projects comply with the enforceable policies of the CZMP. Consistency Review ensures that any federal activities (either projects proposed by a federal agency or permitted by a federal agency) are consistent with the state CZMP. The CZMP includes policies affecting water quality, marine habitat, protected areas, coastal hazards, port/harbor infrastructure, public access, energy, ocean resources, and growth management. The federal government may not take action on a project until the state CZM Office certifies that the project is consistent with the CZMP. For federally permitted projects, an applicant can appeal a consistency determination to the U.S. Secretary of Commerce.

Other State Authorities

Other state agencies may also be involved in a review depending on resources present in a project area. For example, the Division of Fish and Game, Massachusetts Historical Commission, and Massachusetts Board of Underwater Archaeology all review coastal projects for impacts on resources under their respective jurisdictions. In some cases, the review is coupled with review by other agencies, such as MEPA or DEP. In other cases, agencies may have separate permitting processes (for example, if the project results in the "take" of a rare species).

The Division of Marine Fisheries, for example, manages living marine, estuarine, and anadromous resources within the waters of the Commonwealth. The Division may adopt, amend, or repeal all rules and regulations, with the approval of the Governor, necessary for the maintenance, preservation and protection of all marine fisheries resources within its jurisdiction. The Division works closely with NOAA Fisheries, the New England Fisheries Management Council, the Mid-Atlantic Fisheries Management Council, and the Atlantic States Marine

Fisheries Commission to craft regulations that create sustainable, healthy fisheries in compliance with Fishery Management Plans.

Marine Mammals Protection – Federal and State Authorities

In the United States the primary federal legislation that provides for the protection and management of marine mammals is the Marine Mammal Protection Act (MMPA). The federal Endangered Species Act (ESA) also provides protection to the five species of great whales and five species of marine turtles.

Under the ESA, the National Marine Fisheries Service (NMFS) has designated critical habitat for the Right Whale in the New England area in Cape Cod Bay and the Great South Channel. The NMFS Office of Protected Species has also created a multi-organizational Northeast Large Whale Recovery Plan Implementation Team. This team examines the causes of human induced mortality to large whales and proposes ways to reduce or eliminate them.

The Massachusetts Endangered Species Act (MGL: Chapter 131A) and its implementing regulations (321 CMR 10.00) protect the habitats of federal and state listed endangered, threatened and special concern species. The Division of Fisheries and Wildlife works with NMFS in a cooperative agreement for endangered marine species under the provisions of the federal ESA. This allows the Commonwealth of Massachusetts to share management authority for these species with NMFS.

The following is a list of Massachusetts laws and regulations that protect marine mammals:

- Massachusetts General Laws Chapter 130 section 101A provides protection to the gray seal.
- The Massachusetts Division of Marine Fisheries has promulgated regulations (322 CMR 12.00) for the protection of the northern right whale. The regulations establish a 500-yard buffer zone around the right whale.
- The Wetlands Protection Act (MGL Chapter 131, Section 10) includes wildlife habitat as a protected interest of the act. The Act also provides protection for areas designated as "estimated habitat" for state-listed, wetlands-dependent rare species. The Act specifically prohibits a project from causing any short or long-term adverse impacts to the designated estimated habitats of these species. Cape Cod Bay is a designated estimated habitat for the Northern Right Whale.
- The Northern Right Whale is also designated the Commonwealth's official Marine Mammal (MGL Chapter 2 Section 16).

<u>National Environmental Policy Act (NEPA)</u> (42 USC ss 4321 to 4370e and 43 FR 55990)

NEPA established environmental protection as a national policy goal and directed all federal agencies to consider the environmental consequences of their projects and permitting actions. NEPA set up a system for formal evaluation of environmental impacts of the actions of federal agencies, the centerpiece of which is the Environmental Impact Statement (EIS). This document includes an analysis of alternatives to the proposed action, a discussion of impacts from the proposed action, and disclosure of any irretrievable commitment of resources. Typically, a federal agency with an action on a project will prepare an Environmental Assessment.

Following publication in the Federal Register and a comment period, the agency will either issue a Finding of No Significant Impact or will decide to prepare an EIS to more fully examine alternatives, impacts, and mitigation. One federal agency is usually designated as the "lead" agency, and this agency will prepare the EIS. Other federal and state agencies may play an official role in preparation by becoming "cooperating" agencies with the lead agency. At the completion of the EIS process, the lead agency issues a Record of Decision making environmental findings.

Rivers and Harbors Act of 1899 (33 USC ss 401-413 and 33 CFR 323) and Clean Water Act, Section 404 (33 USC s 1251 and 33 CFR 322)

The RHA regulates navigation in waters of the United States, although in recent years the application of the Act has broadened to include environmental considerations. Section 10 of the Act regulates placement of structures in navigable waters. Section 404 regulates discharges of dredged or fill material into waters of the United States. The U.S. Army Corps implements both statutes. For small projects subject to these laws, the Army Corps has issued a Massachusetts Programmatic General Permit establishing general performance standards for all work. For larger projects, individual permit applications are required.

Other Federal Authorities

Other federal agencies may also be involved in a review depending on resources present in a project area. For example, the National Marine Fisheries Service, U.S. Fish and Wildlife Service, Federal Aviation Administration, and Coast Guard review coastal projects for impacts on resources under their respective jurisdictions. In some cases, the review is coupled with review by other agencies, such as the Corps, and/or coupled with analysis in the NEPA process. In other cases, agencies may have separate permitting requirements (for example, if the project results in the "take" of a rare species or marine mammal).

Regional Authorities

Projects located on Cape Cod or Martha's Vineyard (or in waters within municipal boundaries of either) may be subject to review by the Cape Cod Commission or Martha's Vineyard Commission. Both Commissions review projects and must issue a determination that net benefits of a project outweigh negative impacts. Both Commissions review initial project applications to determine if the impacts warrant further review as a Development of Regional Impact (DRI). Review by the Cape Cod Commission is often coordinated with MEPA review. Any project requiring an EIR under MEPA automatically becomes a DRI with the Cape Cod Commission.

Increasing Development Pressure on Ocean Resources

In addition to the more traditional uses of fishing, recreation, and commerce, government regulators are seeing an increasing number of development proposals for a variety of uses of our ocean resources. Seawalls, jetties, docks, and piers continue to dot our coast. The lack of available land-based resources and rapid advances in technology are also driving a new generation of innovative project proposals for potential uses of ocean resources. Proposals for offshore wind energy farms, deep water sand mining, underwater utility infrastructure crossings and pipelines, and aquaculture project proposals are being reviewed, and one can only assume that even more projects and innovative uses are on the horizon. Many of these types of uses were never contemplated when our laws and regulations were drafted, and consequentially have highlighted several policy issues related to appropriate siting and permitting. In the last year alone, government agencies have reviewed or have been consulted about the following types of projects:

Offshore Wind Farms (Cape Wind and Winergy projects) – our need for clean renewable energy, rapid advances in technology, and the strong winds off of our coast are driving forces behind the development of wind energy facilities off of Massachusetts. Six proposed wind farm projects off of the Massachusetts coast have commenced review by state and federal agencies. Three proposals (Cape Wind Nantucket Sound, Winergy Nantucket Shoals, and Winergy Davis Bank) have involved large wind farms in federal waters with cable connections through state waters and onto the mainland. Three other proposed projects (Winergy Falmouth, Winergy Truro, and Winergy Gloucester) involve relatively small (18MW) developments wholly within state waters and lands.

Underwater Electric Transmission and Fiber Optic Cables – New England Electric permitted and built a submarine electric cable (35 megawatt capacity) from Harwich to Nantucket in the mid 1990's. In early 2004, the MEPA review of a second New England Electric cable (this time from Barnstable to Nantucket) was completed. In addition, a third submarine cable connects Martha's Vineyard to the mainland electric grid. Several fiber optic and communications cables also traverse portions of the Massachusetts Territorial Sea, connecting communications infrastructure in Massachusetts to facilities in Europe.

Underwater Pipelines (Duke Energy's Hubline project) – this major infrastructure project, now fully permitted and constructed, involved the development of a new natural gas pipeline in Massachusetts uplands and in the waters of the Commonwealth. The project included 24.8 miles of mainland pipeline and 29.4 miles of predominantly marine pipeline from Beverly harbor to Weymouth. In addition to the state MEPA review and federal NEPA review, more than 10 state regulatory programs and resource agencies were involved in permitting. The major issues during review were water quality, use of public tidelands, and marine fisheries impacts. This project was the first pipeline ever permitted in a Massachusetts ocean sanctuary.

Offshore Sand Mining (DCR's Winthrop Shores) – the demand for high volumes of sand to protect our shores and renourish our beaches is the impetus behind the first major offshore sand mining project proposed in Massachusetts waters. This proposed project would mine one million cubic yards of sand and gravel from the sea bottom to be deposited at Winthrop and Nantasket beaches. While similar projects have been conducted in other states and are contributing to a body of knowledge, much of the data collected pertains to sand mining, as opposed to sand and gravel that is being considered here and that will impact a complex cobble/gravel habitat. This project will also have impacts on water column characteristics, fishes, and invertebrates.

Summary of Key Policy Findings

An examination of the Commonwealth's existing regulatory tools for ocean management and the various types of projects that are being proposed for use of our ocean resources, revealed some policy gaps and shortcomings of the regulatory process that should be addressed by the Commonwealth. The following is a summary of the key findings of the Task Force:

- As the territorial waters of Massachusetts are held by the Commonwealth in trust for its citizens, ocean managers must protect the public's interest in this important resource. A comprehensive ocean management framework could strengthen protection of ocean resources and public trust rights, but should also be flexible enough to encourage uses that benefit the public. These uses may include, but are not limited to, uses that promote public policy objectives such as fostering sustainable fisheries and other water dependant uses, expanding public access to ocean resources, protecting biodiversity, and promoting renewable energy to reduce climate change.

- Ocean management laws, regulations and policies are currently designed to respond to project proposals and are reactive, rather than proactive. No clear mechanism exists for state agencies to create a common vision or plan for the appropriate use of ocean resources.

- The permitting process for ocean project often involves multiple state agencies with overlapping responsibilities and duplicative authority. The permitting process could be strengthened to ensure protection of ocean resources and public trust rights while also improving the clarity and predictability of permitting.

- Compensation for the use of the state ocean resources are artificially low and do not distinguish between types of uses. Furthermore, the revenues generated from such projects are not currently used for ocean-related purposes.

- Coordination among state agencies could be improved with respect to large project permitting and determining appropriate mitigation for potential impacts.

- Compliance and enforcement of coastal laws and regulations should be strengthened and penalties should be better utilized for coastal and marine related protection, restoration, and management activities.

- The current decentralized, single-sector oriented approach to ocean management does not allow for the protection of special resource areas from other potentially conflicting uses. No clear authority exists to create exclusive fishing areas or biodiversity protection area where productive fishing grounds or special resources exist.

- The Commonwealth should continue to strengthen its relationship with federal agency partners where overlapping jurisdiction exists. The Commonwealth should pay particular attention to proposed activities in federal waters that have the potential to impact state resources.

The Policy Frameworks working group originally started as two separate but overlapping working groups of the Ocean Management Task Force (the Frameworks working group was a "subcommittee of the whole" that included direct input from virtually every member of the Task Force). As the Task Force continued its discussions, it became clear that the relationship between a coordinated ocean policy and the framework for an ocean governance structure were inseparable items. For any policy to be fair and effective, there must be a framework in place to ensure coordination among agencies, mechanisms for balancing sometimes-competing interests, and opportunities for the general public and specific ocean interest groups to have effective input into the policy making process. The reverse also holds true- any framework for ocean governance must allow clear articulation of policy goals and ensure an appropriate mechanism for development of policy. This interrelationship between substance (policy) and procedure (frameworks) lead directly to the recommendation for a Comprehensive Ocean Resources Management Act discussed in detail elsewhere in this report. Emphasizing this close relationship, the Policy working group and the Frameworks working group merged into one group and began developing the details of the CORMA. The combined group also recognized that changes to existing regulations, policies, and practices, either in tandem or independent of CORMA, could help further the goal of an integrated system for ocean governance in Massachusetts. These changes to the existing system are reflected in the "Governance" and "Management Tools" recommendations.

APPENDIX

GLOSSARY OF TERMS

Abiotic – any factor in the environment that is non-living (soil, weather, water)

Accretion – the increase of land by the action of natural forces

Amphipods – a group of small, laterally-compressed crustaceans

Anadromous – fish that live in the ocean and enter rivers and streams to spawn (salmon, alewives, shad)

Anoxic – relating to or marked by a severe deficiency of oxygen

Anthropogenic – human-induced (impacts)

Baseline data – basic information gathered before a program or activity begins, to be used later to provide a comparison for assessing impacts; the primary line, the one from which others are measured; often considered the natural state of a system

Bathymetry – the measurement of ocean depth

Benthos/benthic – the community of bottom-dwelling life (e.g. mussels)

Bioassay – appraisal of the biological activity of a substance by testing its effect on an organism and comparing the result with some agreed standard

Biodiversity – the variety of living organisms considered at all levels, from genetics through species, to higher taxonomic levels, and including the variety of habitats and ecosystems

Biogenous sediment – the type of sediment that is made up of the skeletons and shells of marine organisms

Biogeochemical cycle – a circuit where a nutrient moves back and forth between both biotic and abiotic components of ecosystems

Biomass – the total mass of a defined organism or group of organisms in a particular community or an ecosystem as a whole

Bycatch – the harvest of organisms other than the species for which the fishing gear was set; also called incidental catch

Carapace – the shield-like structure that covers the anterior portion of some crustaceans

Catch – the total number or poundage of fish captured from an area over some period of time; includes fish that are caught but released or discarded instead of being landed; may not necessarily be brought ashore (landed)

Catch per unit effort (CPUE) – the number of fish caught by an amount of effort; typically a combination of gear type, gear size, length of time gear is used

Charter boat – a boat available for hire, normally by a group of people for a short period of time

Cohort – a group of organisms spawned during a given period, usually within a year

Crustacean – class of animals that typically live in water and are characterized by jointed legs, segmented bodies, and hard external skeletons (e.g. crabs, lobster, shrimp)

Cryptic species – distinct species that show little or no outward morphological differences, and thus are difficult to distinguish

Cumulative impact – the combined outcome of numerous actions and stresses, where a group of relatively minor impacts may add up to severe habitat degradation or loss

Decapod – a group of crustaceans with five pairs of walking legs and a well-developed carapace

Demersal – organisms that live on or near the bottom

Depuration – purification (shellfish)

Dissolved oxygen – oxygen that is dissolved in water

Easement – the privilege of using something that is not your own (as using another's land as a right of way to your own land); also covers “natural derivatives” of public rights of fishing, fowling and navigation, and the right to pass freely over any inter-tidal areas in order to engage in such an activity

Ecosystem based management (EBM) – integrates knowledge of ecological interrelationships to manage impacts within an ecosystem; effective implementation of EBM should: (1) consider ecological processes that operate both inside and outside ecosystem boundaries, (2) recognize the importance of species and habitat diversity, and (3) accommodate human uses and associated benefits within the context of conservation requirements**.**

Effort – the amount of time and fishing power used to harvest fish; fishing power can include gear size, boat size and horsepower

Embayment – a bay; an indentation of a shoreline larger than a cove but smaller than a gulf

Epibiota – organisms living on the seafloor surface; organisms that attach to other organisms (e.g. barnacles or kelp attached to mussel shells)

Essential fish habitat (EFH) – a designation by the National Marine Fisheries Service for all federally-managed fishery species; 'those waters and substrate necessary for spawning, breeding, feeding, or growth to maturity', as defined by NMFS

Estuary – a semi-enclosed body of water with an open connection to the sea that is measurably diluted by freshwater drainage

Eutrophication – nutrient over-enrichment

Federal consistency review – authority of MCZM to review and approve federal activities in the Massachusetts coastal zone to ensure that federal actions are consistent with CZM program policies and meet state standards. Includes any coastal project that requires a federal license, is implemented by a federal agency, or is carried out with federal funds

Federal waters – generally waters from 3- 200 miles offshore

Fishery – all of the activities involved in catching a species of fish or group of species; one or more stocks of fish which can be treated as a unit for purposes of conservation and management and which are identified on the basis of geographical, scientific, technical, recreational and economic characteristics

Fishery dependent data – data collected on a fish or fishery from sport fishermen, commercial fishermen, and seafood dealers

Fishery resource – any fishery, any stock of fish, any species of fish (commercial and non-commercial species), any prey species, and any habitat of fish; all the living and nonliving resources, substrate and ecological systems which fish species need to survive

Fisheries independent data – data collected on a fish by scientist who catch the fish themselves, rather than depending on fishermen and seafood dealers

Fishing mortality – a measurement of the rate of removal of fish from a population by fishing; “annual”- percentage dying in one year, “instantaneous”- percentage dying at any one time

Fork length – the length of a fish as measured from the tip of its snout to the fork in the tail

Fouling organisms – organisms that live attached to human-made surfaces such as boats and pilings (e.g. bryozoans, sponges)

Geographic Information Systems (GIS) – a computerized system of organizing and analyzing any spatial array of data

Greenhouse effect – the increase in the earth’s temperatures that results from the presence of carbon dioxide and other heat-trapping gases in the atmosphere

Habitat – the type of environment in which an organism or group of species normally lives or occurs

Hypoxia – a deficiency in oxygen

Incidental catch – See Bycatch.

Infauna – the animals that burrow in the substrate (e.g. polychaetes, small bivalves)

Juvenile – an organism that has not yet reached sexual maturity

Landings – the number or poundage of fish unloaded at a dock by commercial fishermen or brought to shore by recreational fishermen for personal use; reported at the points which fish are brought to shore (not necessarily areas where caught)

Littoral – the zone between the highest and lowest spring-tide shorelines; the inter-tidal zone

Marine invasive species – or aquatic nuisance species, are non-native plants and animals are transported into and throughout Massachusetts via commercial shipping, as fouling organisms on recreational boats, through the release of unwanted aquarium contents, or a variety of other human related transport vectors; have great potential for rapid colonization and are already having significant impacts on the biodiversity and integrity of aquatic habitats

Marine protected area – any area of the marine environment that has been reserved by federal, state, territorial, tribal or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein (as defined by Executive Order 13158; May 26, 2000, Federal Register)

Metadata – summary data providing content, quality, types and spatial information about a data set; used in GIS mapping and other applications

Nearshore – referring to shallow waters close to the coast

Neonate – a newborn

Neritic – the pelagic environment above the continental shelf

Offshore – referring to deeper waters far from the coast

Opportunistic species – species which have short life spans, the ability to reproduce quickly in large numbers and have generalized environmental requirements

Ova – eggs

Oviparous – an animal that releases eggs

Paralytic shellfish poisoning – a condition caused when humans eat shellfish that have become contaminated with the toxin present in the dinoflagellates that cause red tides

Parturition – birth

Pelagic – organisms that inhabit the water column/open sea, and spend relatively little time on the sea bottom (e.g. tuna, some sharks, jellies, plankton)

Perturbation – the disturbance of the quality of natural resources caused by human activity/use or natural processes

Phytoplankton – the photosynthetic, plantlike plankton

Plankton – the plants and animals that are found drifting in the water

Recruitment – the measure of the number of organisms that enter a class during some time period, such as the spawning class or fishing-size class

Relative abundance – an index of fish population abundance used to compare fish populations from year to year; doesn't measure actual numbers of fish, but shows population changes over time

Remote sensing – any technique for analyzing landscape patterns and trends using low altitude aerial photography or satellite imagery; any environmental measurement that is done at a distance

Seining/seine – a large fishnet that hangs vertically, with floats at the top and weights at the bottom, that will enclose fish when it is pulled in

Sessile – permanently attached to the substrate and not free to move about (e.g. adult barnacles, bryozoans)

Species richness – number of species in a region, site or sample

State waters – generally extending from coastline to 3 nautical miles offshore, with the exception of areas within Massachusetts Bay, Cape Cod Bay and Nantucket Sound that extend further due to bay closure lines established by the U.S. Supreme Court

Stock assessment – an estimation of the amount or abundance of the resource, an estimation of the rate at which it is being removed due to harvesting and other causes, and one or more reference levels of harvesting rate and/or abundance at which the stock can maintain itself in the long-term

Strata/stratum – geographic zones

Stratified mean weight – unit of measurement for trawl surveys (per tow)

Submerged lands – tidelands lying seaward of the low water mark; under state jurisdiction

Substrate – the type of bottom or material on or in which an organism lives

Synergistic interaction – an interaction that has more than additive effects, such as the joint toxicity of two compounds being greater than their combined, independent toxicities

Taxon/taxa – a group of organisms that share a common ancestry

Temporal – of or relating to time as distinguished from space

Territorial waters – state waters extending from the shoreline to 3 miles offshore, except for Massachusetts Bay and Cape Cod Bay

Topography – the configuration of a surface area including its relative elevations and the position of its natural features

Trophic level – a nourishment level in a food web; plants and other primary producers constitute the lowest level, followed by herbivores and a series of carnivores at higher levels.

Turbidity – the amount of particulate matter suspended in water

Wetland – *coastal*– any bank, marsh, swamp, meadow, flat or other lowland subject to tidal action or coastal storm flowage; *freshwater*- where groundwater, flowing or standing surface water or ice provide a significant part of supporting substrate for a plant community for a lease 5 months out of the year

Year-class – the fish spawned and hatched in a given year, a "generation" of fish

Young-of-the-year (YOY) – fish that are less than one year old; born during the spawning season

Zooplankton – the heterotrophic, animal component of plankton

These definitions have been adapted from the following sources:

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Task Force Meeting Schedule

This is a comprehensive list of all meetings of the full Task Force. Please note, additional meetings of several work groups occurred between September 2003 – February 2004.

June 17, 2003, 1 PM – 4:30 PM, Mariner's House, Boston

July 30-31, 2003, 9 AM – 5 PM, John Joseph Moakley Courthouse, One Courthouse Way, Boston

September 5, 2003, 9:30 AM – 5 PM, Essex Conference Center and Retreat, Essex

September 15, 2003, 10 AM – 2 PM, Coastal Zone Management Offices, 251 Causeway Street, Suite 800, Boston

October 17, 2003, 9 AM – 3 PM, New England Aquarium Education Center, Central Wharf, Boston

November 24, 2003, 10 AM – 3 PM, Woods Hole Oceanographic Institution, Clark Lab, Room 522, Quissett Campus, Woods Hole

December 19, 2003, 10 AM – 1 PM, Fort Taber, New Bedford

January 27, 2004, 9:30 AM –2:30 PM, Division of Marine Fisheries Annisquam Lab, Gloucester

February 12, 2004, 9 AM – 12 PM, U.S. Environmental Protection Agency, One Congress Street, Boston

February 26, 2004, 10 AM – 3 PM, Children's Museum of Boston

Public Information Meetings

Boston
December 10, 3 PM - 5 PM, John Joseph Moakley Courthouse, 1 Courthouse Way

Worcester
December 10, 7 PM - 9 PM, Broad Meadow Brook, 414 Massasoit Road

Yarmouth
December 11, 7 PM - 9 PM, Yarmouth Council on Aging, 528 Forest Road

New Bedford
December 15, 7 PM - 9 PM, New Bedford Public Library, 613 Pleasant Street

Gloucester
December 15, 7 PM - 9 PM, Cape Ann Historical Association, 27 Pleasant Street

LIST OF PUBLIC COMMENTERS

Public comments were submitted by the following list of individuals by name and town, where this information was provided. All comment letters are available for review at http://www.state.ma.us/czm/MOMI/commentsrec.htm

Name/Position	Affiliation/Location
Jan Smith, Director	Massachusetts Bays Program
Eric Chivian, M.D., Director	Center for Health and the Global Environment, Harvard Medical School
Jessica Almy, Wildlife Advocate	Human Society of the United States Cape Wildlife Center
David Bergeron	Massachusetts Fishermen's Partnership
Gib Chase	U.S. Fish and Wildlife Service
George M. Woodwell	Woods Hole, MA
David H. Owen	Rochester, MA
Michael B. Jacobs, Treasurer	HullCARES
Mark Weissman	Mashpee, MA
Robert O'Leary, State Senator	Cape and Islands District
Peter R. Borrelli, Executive Director	Center for Coastal Studies
Maria Marasco, Esq.	Andover, MA and South Yarmouth, MA
Susan L. Nickerson, Executive Director	Alliance to Protect Nantucket Sound
Cindy Lowry, Director	Oceans Public Trust Initiative
John Darwin	Fairhaven, MA
Gerard Dhooge, President	Boston and New England Maritime Trades Council, AFL-CIO
Dennis J. Duffy, VP of Regulatory Affairs	Cape Wind
Robert J. Gough, Director, and Barbara Warren, Program Director	Salem Sound Coastwatch
Don C. Hayward	Monument Beach, MA
John Brierley	
Captain David DeCastro	Pembroke, MA
Robert Bartolini	Franklin, MA
Rodger Ballou	
Tom King	Scituate, MA
Harry Cockran, Berl Hartman Myron Kassaraba, Daniel Goldman, and Christopher Kaneb, Co-founders	E2 New England
William Eddy	Falmouth, MA
Captain Tom Deprsia, President	Stellwagen Bank Charterboat Association
Captain Mike Sosik, President	Northeast Charter Captains Association
Fara Courtney	Good Harbor Consulting
Bruce Humphrey	BioAquamatics
Cara Metz, St. Historic Preservation Ofcr.	Massachusetts Historical Commission
David Begelfer, Chief Executive Officer	National Association of Industrial and Office Properties
John Pollock	Dedham, MA
Joseph Kwasnik, VP- Environment	National Grid

Name/Position	**Affiliation/Location**
Gouldston and Storrs, Peter. D. Corbett, Attny.	New England Development and Nantucket Boat Basin LLC
Robert H. Russell	Strategic Environmental Consulting
Jay M. Cashman, Chairman of the Board	Cashman Constructors
Jonathan G. Davis, Chief Executive Officer	The Davis Companies
Margaret Rowland	
Walter Thompson	
John Cregan	Nantucket, MA
Robert diCurcio	Nantucket, MA
Steve Hirsch	
Martin Lempres	Wellesley, MA
J. Turner	
John Paone	Mashpee, MA
Captain Nola Assad	USCG, OUPV, Yarmouthport, MA
Ailibali	New Seabury, MA
Anne and James Lagrippe	New Seabury, MA
Richard Ulian	Coituit, MA
Erin Madden	Hyannis, MA
Leon Mir	Chestnut Hill, MA
Janet Lloyd	Cambridge, MA
David Bullock	
C. Richardson	
David Robinson	N. Andover, MA
Sheridan Carey	Westwood, MA
Tim Albright	
Auntieshrew	
Paul and Katie Wylie	Hyannis, MA
Roger Stoll	
Lee Hayes	
Townsend Hornor	
Richard Roach	U.S. Army Corps of Engineers
Iain McGill	Quincy, MA
Peter Beves	Holbrook, MA
Catherine Greenleaf	Vineyard Haven, MA
William F. Dubiel	Osterville, MA
Richard Mullin	South Dennis, MA
Jeanine Bandiero	
Milton Thomas	
Richard and Phyllis Campobello	Osterville, MA
James Curtis	Edgartown, MA
Mike McCaffery	
Maureen Darling	
David Breski	Marstons Mills, MA
Jim Ferry	
Laura Caruso	Billerica, MA
C. Frances	
Pricilla R. and Joseph L. Lucier	Osterville, MA
Bruce May	Middleboro, MA

Name/Position	Affiliation/Location
Jane K. Bright and Lori Ehrlich (on behalf of)	HealthLink Board of Directors
Adam R. Hundley, Attorney	Winn Development Company, Noodle Island Limited Partnership
John Binienda, Chairman, and Daniel Bosley, Chairman	Joint Committees on Energy and Government Regulations
Patrick Tiberio	Mansfield, MA
Julius Marcus	
Wendy K. Northross, CEO	Cape Cod Chamber and CVB
Patrick J. Hester, VP, General Counsel	Duke Energy Gas Transmission-East
Michael J. Doebley, Deputy Dir. for Gov't Afs.	Recreational Fishing Alliance
Jim Klocke, Executive VP	Greater Boston Chamber of Commerce
Mike Flaherty, Vice President, and Patrick Paquette, Gov't Affairs Liaison	Massachusetts Striped Bass Association
Neal Costello, General Counsel	Competitive Power Coalition of New England, Inc.
James E. Liedell, Operations Director	Clean Power Now
Maggie Geist, Executive Director	Association to Preserve Cape Cod
Nancy A. Thornton, Dir. of Waterways	Department of Conservation and Recreation
Samuel J. Bennett	Marblehead, MA
Alice	Centerville, MA
Mark Rasmussen, Executive Director	Coalition for Buzzards Bay
Charles T. Casella	Georgetown, MA
Carl Redfield	Osterville, MA
Albert H. Benson	U.S. Department of Energy Boston Regional Office
John C. Phillips, New England Reg. Director	The Ocean Conservancy
Charles W. Kleekamp, Info. Dir, VP	Clean Power Now and Cape Clean Air
Gene Soccolich	Mattapoisett, MA
Mary Ann Nelson, Chair	Massachusetts Chapter of the Sierra Club
Jacqueline Odell, Executive Director	The Northeast Seafood Coalition
Bernie Feeney, President	Massachusetts Lobstermen's Association
Peter Murray	Bridgewater, MA
Victor T. Mastone, Director	Board of Underwater Archaeological Resources

Form letter—Comments received from several fishing organizations/individuals interested in fisheries resources:

Robert Baranek, President, MSBA, Weymouth; Mike Flaherty, Quincy; Merrill C. True, Jr. Freetown; Daniel Berkman, Boston; Peter Murray, President, Massachusetts Beach Buggy Association, Bridgewater; Joe McCabe, Scituate; Van Christie, Quincy; Donald W. Shaw, Burlington; Captain Michael F. Sosik, Jr., Northeast Charter Services, Inc., Sturbridge; Glenn Drabik; George A. Lemieux, Jr., Bradford; Captain Dave Auger, Harpoonist Fishing Charters, Newburyport; Mike Delzingo, Arlington; Matthew Moses, Dedham; Julianne R. Silvis, Quincy; William E. Bryant, Quincy; Willy Goldsmith; Michael J. Bucko, Bucko's Parts + Tackle, Fall River; Cheryl Flaherty; Jim Taniyama, South Kingstown, RI; Tom Sousa; Dan Dennehy, Quincy; Chuck Morrison, Marshfield; Scott Gray; Captain Robert McCue, President, Bounty Hunter Sport Fishing, Inc.; Wallace Moore, Needham; Barbara Moore, Needham; Matthew Moore, Needham; Michelle Moore, Needham; Kristen Moore, Needham; Erin Moore, Needham; Edward E. Miller, Plympton,; Scott West, Duxbury; Captain Debbie DePepersia, Marshfield; Dennis Hogan, Jamaica Plain; Michael C. Sawyer, Plymouth; John Donovan, Shrewsbury; Vincent Kelleher, Rockland; John Comeau; David Brite; Steven E. James, President, Boston Big Game Fishing Club, Marshfield; Luke Cantella, Plymouth; George Turner, Easton; Elden Ip, Pembroke; Jarrod Morrison, Marshfield; John Fitzgerald; Peter Asiaf; Captain Dave Waldrip, Nautical Adventure Charters, Rockland; Bruce A. Bornstein; Jeffrey Bolster; Frank O'Rourke; East Bridgewater; Michael W. McGuigan, Shirley, NY; Michael A. Doto, Medford; Harris A. Tracy, Stoughton; Toby Scott-Lapinski, South Hadley; Richard C. Kozlowski, North Reading; William N. Hovanasian, Salem; Steven Cannizzo, Dartmouth; David Kupfrian, Tewksbury; David Duffy, Gloucester; Dave Barrett, Tyngsboro; Michael F. Elrick, Plymouth; Rick Elrick, Quincy; Matthew Baer, Elmwood Park, NJ; Steve Connors.

Form letter—Comments received from citizens of the Commonwealth concerned with the current state and future health of Massachusetts ocean life:
Ann Gleason, Boston; Theodore Field, Osterville; Jan Oleson, Watertown; William Galli, North Adams; Carol Nealy, Monson; Kenneth Bozek, South Hadley; Nanette Oggiono, Upton; C. Lee, Roxbury; Ruth Clarke-Smith, Hudson; Joy Chambers, Shrewsbury; Haidee LeClair, Berlin; Gail Herath-Veiby, Westborough, Ellen Podolsky, Medford; Robert Miller, Winthrop; Judy Desreuisseau, Gill; Christine Caramanica, Peabody; Jerry Vinal, Whitman; Audrey Higbee, Granby; Sherry Weiland, Arlington; Deborah Hastings, Pittsfield; Dierdre Millman, Hudson; Philip F. Tomlinson, Jr., Greenfield; Patricia J. Jennings, Winchester; Timothy O'Neil, Maynard; Jessica Babineau-Dupont, Fitchburg; Karin Statkum, Quincy; Matt Fitzgibbons, Auburn; Donald Blickens, Sagamore Beach; Brenna Hughes, Marshfield; Katherine Lester, Eastham; Juanita Martinez, Springfield; Katharine Madjid, Cambridge; Phyllis Troia, Plymouth; Christine Caton-McGill, Quincy; Stephen Donnelly, Easthampton; Annie Laurie, Dracut; Carol Carson, Middleborough; Cathy Gardner, Kingston; Hal Fales, Leeds; Patricia Panitz, Centerville; Atin Garg, Lexington; Cynthia Lovell, Charlestown; E. Smith, Beverly; John O'Brien, Chelsea; Alison McCabe, Cambridge; Carl Macrae, South Yarmouth; Martha Olver, Amherst; Eileen Tennant, Arlington; Laura Monti, Chicopee; Martha Leahy, Winchester; Barbara Brown, Lakeville; Jim Crowley, Cambridge; Fred Pomerantz, Sheffield; Dr. Lenny Cavallaro, Ipswich; Chris Buelow, Hardwick; Andrew Levin, Wellesley; Sara Genthner, Easthampton; Cynthia Chapman, Scituate; Catherine Clark, Orleans; Katie Mae Simpson, Malden; Stacey Rossi, North Adams; Judith Embry, Florida; Kit Hoffmann, Randolph; Holiday Houck, Boston; Nathaniel Bellinger, Jamaica Plain; Arline Heimert, Winchester; Julia Max, Newton; Annett Albert, Revere; Karen Ziomek Vayda, Easthampton; Jason Roberts, Somerville; Richard Tonachel, Cambridge; Jill Connor, Medford; Laurie Williams, Wareham; Alan Papscun, South Egremont; Bethany Silveira, Clinton; Jenn Farnum, Greenfield; Elizabeth Way, Upton; L. Gols, Natick; Janice Edwards, Milton; Ann Hunt, Hinsdale; Patricia Titterington, Northampton; Nicole Macguire, Malden; Trinity Peacock-Broyles, Jamaica Plain; Andrew Stahl, Wayland; Marian Kelner, Greenfield; Mary-Alice R. Austin, Belchertown; Courtney Newman, Dedham; Margaret Rydant, Northborough; Amanda Thomas, Chicopee; Keith Morehouse, Falmouth; Suzanne LeMieux, Springfield; Regan Maund, Arlington; Jaremy Lynch, North Easton; Brent Hymer, Burlington; Chris Tarr, Monson; Julianne Rovello, Medford; Carrie Gilbert, Springfield; Renee Holesovsky, Amherst; Chelsea Bouchard-Harnish, East Falmouth, Janet Erickson, Wellfleet; Jeffrey Laurie, Tyngsboro; Catherine Fidalgo, New Bedford; Kristen Paiva, Stoneham; Donna Hampson, Ayer; Jesse Kaminsky, Brighton; Amy Tatem, Salem; Judith Auerbach, Winthrop; Carol Vivori, North Adams; Jeffrey W. Jones, Northampton; Mark Knowles, Rehobeth; Alex Weiland, Arlington; Tom Abbe, Newton; Eleanor MacLellan, Chestnut Hill; Rachel Willman, Norfolk; Amelia Scarpa, Peabody; Bruce Drucker, South Wellfleet; Katharine O'Donnell, Quincy; Robbi Laak, North Grafton; Michael Wallace, Abington; Fritz Bosch, Medford; Cheryl Vallone, Ashland; Karissa Bernardo, Hudson; Melanie Mahin, Arlington; David Goodman, Malden; Justin Balch, Cambridge; Sally Elliott, Dighton; Cindy Warner, Greenfield; Gail Cavanaugh, Weymouth; Kaisa Koponen; Diane Down, Foxboro; David Tavilla, Somerville; Barbara Birdsey, West Barnstable; Dough Shohan, Lee; Cynthia Bradford, Marlborough; Mary Madden, Boston; Kristine Acevedo, Revere; Bethany Silveira, Clinton; Bruce Cohen, Millbury; Tracy Thrasher Hybl, Nahant; Jenny Jones, Natick;

Jaimie Golec, Florence; Heather Walleston, Allston; Robert Mast, Concord; Elisabeth Stoeckel, Boston; Christina Dropo, Weymouth; Tanya Anderson, Cambridge; Jeff Migdow, Lenox; Jamie Shohan, Lee; Erin Abrams, Sturbridge; Paul Bernstein, South Lawrence.

Form letter—Comments received from the Alliance to Protect Nantucket Sound
Anne Hart, Worcester; Karim Basta; Keith Bernard; Molly Herod, Richardson, TX; Todd Adelman, Newton; Emily George, Richardson, TX; Bill Varga, Cotuit; J. Bruce Gabriel, Marlborough; Tangley DeLaney, Hyannis Port; Brian J. Hawkesworth, Secretary, Dennis, Waterways Commission, Dennis; Jackie Connor; Peter and Patricia Ward; Richard Brand, Hyannis Port; Judith Brand, Hyannis Port; Dan and Maria Gallagher, West Simsbury, CT.

SUMMARY OF IMPLEMENTATION PLAN RESPONSIBILITIES TO AGENCIES

GOVERNANCE

Recommendation	Description	Implementation
Comprehensive Ocean Resources Management Act (CORMA)	The Secretary of Environmental Affairs should introduce legislation for a new, comprehensive Ocean Resource Management Act	• The Secretary should convene an inter-agency working group to draft legislative language for a new Ocean Resource Management Act, and to begin to work with interested groups and the legislature to shape a legislative package for the Act. • We do not recommend that any moratoriums be imposed during the pendancy of this process. • We do, however, recommend that the state move expeditiously to draft, enact and implement a new Act and prepare the subsequent plans so that they can play the important roles in the future that we envision for the protection and appropriate use of the state's ocean resources.
Ocean Management Coordination	The Commonwealth should actively promote federal/regional/state cooperative ecosystem management	• EOEA should proactively continue to expand these frameworks and review and amend its enforceable coastal policies with assistance and approval of federal partners.
Climate Change Plans	The Commonwealth's Climate Change Action Plan should include actions relating to effects of climate change on our coasts and oceans	• The Secretary should ensure that ocean issues are well represented in the state's climate change action planning efforts and should task CZM with participating in Plan development and implementation as it affects coastal and ocean issues as well as coordination with similar federal initiatives.
Ocean Sanctuary Act Revisions	The regulations implementing the Ocean Sanctuaries Act (OSA) (302 CMR 5.00) should be updated	• The Secretary should convene a workgroup to develop recommended revisions to existing OSA regulations. Specific issues to address include, but are not limited to, clarification of the Public Necessity and Convenience Test for the purposes of considering whether to allow certain development projects within the ocean sanctuaries, the definition of and standards relating to "significant alteration," and the development of guidance or standards relating to aesthetic impacts. • As a subset of the workgroup process, an interagency workgroup should be convened to draft a Memorandum of Understanding that specifies and formalizes the roles and responsibilities of agencies that participate in OSA implementation. • This workgroup process should keep up-to-date on the status of enactment of a new Ocean Resources Management Act, in order to assure that the drafting of such legislation incorporates and addresses the types of protections set forth in the OSA, and then also provides for the elimination of the OSA upon enactment of such an Ocean Resources Management Act with such provisions.

MANAGEMENT TOOLS

Recommendation	Description	Implementation
Fee structures	Current Chapter 91 license fees in offshore waters– should be examined and adjusted (i.e., increased or decreased) where appropriate	• The Commonwealth should undertake a study to research "best practices" in Massachusetts and other jurisdictions relating to the setting of fees in other policy areas (not necessarily having to do with the oceans, but in areas where a fee is designed to reflect "non-market" values associated with permitted or licensed development activities on a public resources (e.g. the radio spectrum, grazing fees, offshore oil royalties)). • The Commonwealth should convene a working group to advise DEP on options for setting Chapter 91 fees, including through obtaining public comment on a specific set of proposed fees. • The working group should define and map the proposed area to be subject to a revised Chapter 91 fee structure.
Marine Protected Areas	The Secretary of Environmental Affairs should convene a working group to develop recommendations regarding the designation of Marine Protected Areas	• The Secretary should establish an interagency working group, composed of the relevant state and federal agencies, co-chaired by DMF and CZM, and with input from a stakeholder advisory group.
Coordination of Mitigation	Interagency coordination of project mitigation should be improved	• The Secretary, through the MEPA director, should designate a lead agency staff person whose responsibility would be to ensure that permitting and resource management agencies coordinate their actions and requirements, and that the MEPA process reflects the concerns of the permitting and reviewing agencies. • Development of a restoration priority list should be undertaken by EOEA in consultation with appropriate permitting and reviewing agencies.
Enforcement	Enforcement of existing environmental laws should be a high priority	• Once the list of priority projects is developed, the state agencies with enforcement authority should seek to tie implementation of projects on the list to their enforcement actions. For example, implementation could be mandated through the process of developing Consent Orders.
Visual, cultural, and aesthetic impacts	Methodologies and standards for the analysis of visual, cultural, and aesthetic impacts of proposed projects in state waters should be developed	• The Secretary should appoint an interagency work group to develop standards for visual, cultural, and aesthetic impacts for adoption by the relevant agencies. • To initiate this project, EOEA should task an intern with undertaking a literature search on this topic to reveal what approaches are being used in different areas.
Use Characterization	Inventories of the uses and resources of the state's marine waters should be developed.	• A working group representing state and federal agencies, non-governmental organizations, commercial and recreational fisheries, maritime industries, energy, recreational boating, homeland security, defense agencies, and GIS systems and products should be created. • This working group should establish standards for use characterization, obtain relevant use information, determine how best to represent and display the information, and ensure its dissemination among the public. This work group should work closely with area resource data specialists.

SCIENTIFIC UNDERSTANDING

Recommendation	Description	Implementation
Marine and Ocean Resource Trends Advisory Group	An advisory group of marine and fishery scientists should be appointed to advise the state	• An advisory group should be appointed to outline the scope of this recommendation, including identifying priority species and habitats and appropriate temporal baseline levels. • At the completion of each historical trends analysis, the advisory group should prepare a report that explains the trends analysis process and provides guidance for how marine resource managers should use the information.
Ocean monitoring and research	A comprehensive ocean resources monitoring and research plan should be developed	• A working group, comprised of state and federal agencies, non-governmental organizations, fishery representatives, and public interest groups, should be established and tasked with outlining the components of a comprehensive monitoring and research plan for the Commonwealth of Massachusetts. • The work group should summarize existing monitoring programs, evaluate effectiveness of current monitoring, and recommend improvements to statewide monitoring.
Seafloor Mapping	The Commonwealth should acquire seafloor maps	• Development of a strategic plan to obtain seafloor habitat maps should be led by the existing (informal) Interagency Marine Habitat Working Group organized by CZM, with involvement from federal and state agencies, non-governmental organizations, researchers, and fishermen.
Standardized Protocols for Data Collection	Standards should be developed for monitoring data submitted by project proponents	• An inter-agency group composed of environmental agencies should be tasked with developing standardized data collection protocols, to the maximum extent possible. Additionally, an interagency work group should evaluate on-going monitoring programs and periodically make needed changes to these programs.

OUTREACH

Recommendation	Description	Implementation
Ocean Literacy and Stewardship	The Secretary should commit to developing a new ocean literacy and stewardship ethic among all citizens of Massachusetts	• The Task Force recommends that the Secretary of Environmental Affairs immediately launch a school-based Ocean Education project as a part of the Ocean Management Initiative. • The Secretary should expand her existing Ocean Education Working Group to include key ocean education programs and participants such as the Department of Education. The group should develop a strategic plan to coordinate the existing programs, expand programs to underserved communities, establish linkages between science and education programs, ensure that targeted outreach is undertaken and identify resources necessary to implement the plan. • An advisory group should be assembled to fully explore options and guide the creation of a sustainable broader outreach plan. The outreach plan should draw upon, and complement, local, regional, national efforts to improve ocean literacy. The advisory group should represent broad interests, cutting across traditional sectors.
Dissemination of ocean resource data	Public dissemination of certain data collected on the Commonwealth's resources, should be increased	• To fully realize the value of ocean resources data collected in Massachusetts and to insure appropriate application of these data to ocean resources management, a thorough list of data sets needs to be compiled and organized. • Agencies that collect substantial volumes of data, manage projects that generate data, review permit-related data and provide state-issued scientific permits used to generate data should be responsible for supplying such data to a statewide index.